TOPICS OF THE MONTH

Uranium processing achievement

SOME impressive chemical engineering has gone into the £12-million factory for processing uranium, now being commissioned at Springfields, Lancs., and some further interesting developments should be seen there. With the new plant, the United Kingdom Atomic Energy Authority will be able to increase production and reduce operating costs.

Springfields, which has produced nearly a million fuel elements since it started operations in 1948, is the source of supply for the atomic reactors at Calder Hall and Chapelcross, as well as for the *Bepo* reactor at Harwell. Shortly, this work will be extended to include the manufacture of fuel elements for the nuclear power stations being built by the industrial consortia for the electricity undertakings both at home and overseas. The plant was originally planned to use pitchblende as the starting material and this, after being converted to a slurry, went through various heating, filtering and other operations before the final uranium was obtained.

The new process is planned to use concentrate, *i.e.* a crude uranium oxide, as the starting material, thereby eliminating the peroxide precipitation stage of the original process. The concentrate is fed into large, stainless-steel tanks fitted with steam-heating coils and stirrers, where it is dissolved in nitric acid, the solution being passed, after cooling, through rotary filters. Re-slurrying and re-filtering of the filtrate is then carried out. The uranium solution is then purified by solvent extraction with a solution of tributyl phosphate (TBP) in odourless kerosene in mixer-settler units arranged in cascade. In this process, the removal of uranyl nitrate from the aqueous phase can be made almost complete. At the top of the plant the tributyl phosphate emerges containing the uranyl nitrate in solution, passes through a heating unit and the uranyl nitrate is then washed out of the solvent by a weak nitric acid solution.

Here the process at present reverts to the original. The uranyl nitrate solution is treated with ammonia to precipitate the uranium as ammonium diuranate. This compound is then put through the *Dryway* plant to emerge as uranium tetrafluoride. Ultimately it is planned to carry out this part of the process by fluidised-bed methods and development work is at an advanced stage. The section of the new plant in which this will be done is at present under construction. The subsequent stage of converting uranium tetrafluoride into the pure metal now uses magnesium as a reducing agent instead of calcium as was employed in earlier days.

Further operations at Springfields include the conversion of the uranium metal into fuel elements, which are canned in magnesium alloy. Altogether this well-planned factory represents a remarkable advance since the days, not so long ago, when know-how on the manufacture of uranium metal on this scale was practically non-existent and the hazards involved in the tonnage handling of radioactive material were unexplored.

Getting our money's worth of research

EVEN the Americans are getting depressed about the high cost of research. The latest remedy is one which we would not expect to be proposed in a country dedicated to free enterprise and individualism. It is the remedy of co-operatively sponsored research whereby companies would pool their research resources to avoid duplication of effort. This suggestion was made by Mr. L. G. Bliss of Foote Mineral Co. at a recent meeting of the Manufacturing Chemists' Association in New York. He argued that the industry could no longer afford the luxury of repeating research to get information already obtained and urged that the M.C.A. should encourage its members to co-operate in research. He even suggested that the Association should advise on the spending of research funds, deciding, for instance, how much pure research the industry should support.

We hardly feel that this suggestion would find universal favour in the U.S. any more than it would in Britain, for the simple reason that in both countries there are very large chemical companies who would find it no advantage at all to engage in co-operative research. Companies like du Pont and I.C.I. have the men, money and facilities to carry out research on a large scale, and it would be too much to expect them to have sympathy for the troubles of smaller competitors.

Of course the root of the problem of duplication of research is information. First of all a firm must be prepared to spend money on a good information service to ensure that all literature within its field of activity is made available to its technical staff. Secondly firms must give as well as take, *i.e.* they must be prepared to publish results of work done in their own laboratories. Often this is not done not because of an obsession with secrecy but simply because it is no one's job to do it.

As far as the collection of information goes, the new scientific and technological lending library to be set up by the Department of Scientific and Industrial Research (see our 'Technology Notebook' column) should prove a blessing to British firms. For all the hard things that are said about it at times, the D.S.I.R. is doing a good job of helping industry with its scientific and technical problems. The D.S.I.R. has recently announced plans to double the expenditure on research in the next five years and some £61 million is to be made available to the Department for its second five-year plan. Significant, also, is the

decision to devote much more attention and more money to ensure that the results of scientific research are known and applied.

The largest expansion is planned to take place in the field of scientific grants to the universities. Post-graduate awards to students will be increased by about 10% each year until in 1963-64, it is hoped, some 3,800 students will be receiving D.S.I.R. grants for research training. In the same year it is expected that D.S.I.R. support for special research in the research departments of universities will be operating on a scale of about £1¾ million p.a.

In support of additional research carried out in the Department's own laboratories, expansion of staff at the rate of about 6% p.a.—approximately 30% over the five years—is included in the plan. Grants to the Research Associations will also be increased to over £2 million p.a. by the end of the period. At present there are 49 organisations in the D.S.I.R. scheme. The Council for Scientific and Industrial Research will continue its policy of encouraging industry to bear an increasing proportion of the total cost. It may be expected, therefore, that the actual expansion of the R.A. movement will be proportionately greater than the increase in Government grant.

Industry v. Corrosion—Round 2

NEW production processes and new technical advances come and go, but corrosion remains as one of the chemical engineer's biggest problems. How much does corrosion actually cost a country like Britain? Has the cost gone up or down since it was estimated, in 1955, that Britain's annual bill for corrosion, including expenditure on protective measures, was £600 million?

The introduction of a new campaign against corrosion since that time indicates that more money is being spent, now, on protective measures. Against that, the savings on equipment that would otherwise have to be scrapped because of corrosion are bound to show an increase.

This brighter state of affairs is due in no small measure to the impact of the 1957 Corrosion Exhibition and Convention, which drew some 8,000 visitors to London and stirred the corrosion-consciousness of a good many more. But a persistent enemy like corrosion is not likely to be put to rout by one single attack and so it is welcome news that a new and even bigger anti-corrosion show is being planned for this year. It is appropriate that it is to be opened by Sir Owen Wansbrough-Jones, K.B.E., C.B., who, as Chief Scientist of the Ministry of Supply, runs one of the biggest scientific organisations in the country. Protecting hundreds of millions of pounds worth of Armed Forces' equipment against corrosion damage is a major task of M.O.S. scientists.

Over 70 firms will be showing at the Corrosion Exhibition, which will be held from April 27 to 30, inclusive, at the Royal Horticultural Society's New Hall in Westminster, London. There should be much to interest users, designers and manufacturers of chemical plant. Tickets for the Exhibition are available from the organisers, *Corrosion Technology*, Leonard Hill House, Eden Street, London, N.W.1.

Electricity from ceramics

THE direct conversion of heat into electricity, efficiently and economically, is a tantalising prospect that has led to the development of such devices as the fuel cell, the thermionic converter of the General Electric Co. in America, and the thermo-electron engine developed at the Massachusetts Institute of Technology. A new, unusual approach to the problem is seen in the thermo-electric ceramic materials on which the Westinghouse Electric Corporation is working. These materials are thought to be the first solid-state thermo-electric substances to operate at promising efficiencies at temperatures in the range of 2,000 to 3,000°F. Being ceramics, they are inherently stable and chemically inactive, even at very high temperatures. They can be heated indefinitely in air with an open flame without deterioration; they do not require chemical preparation to an extreme degree of ultra-purity; their use raises no technological problems of high-vacuum operation, or complex electrical or electronic apparatus.

The work with these new thermo-electric materials is still in its early stages, and they do not exhibit the efficiency demanded by conventional methods of power generation. However, for specialised applications, where compactness, light weight and simplicity are more important than efficiency, these materials offer promise for practical applications requiring small quantities of electric power.

Calibrating a pressure gauge

A SIMPLE and efficient means of labelling and calibrating blank dials for pressure gauges has resulted from a suggestion from an instrument charge-hand at Imperial Chemical Industries Ltd., Billingham. The idea relates to 3 to 15 p.s.i. receiving pressure gauges of the sort used in industrial processes to respond to the output of transmitting instruments which may measure, for example, 0 to 40 tons, −30° to +30°C., or 0 to 300 cu.m./hr.

As described in a recent issue of *Target*, the device consists of a plastic base plate to which is fitted a plastic disc sub-divided into 270 degrees. The blank is fitted flush into the disc—which has been cut away in the centre and screwed down at two points. A radial arm is then screwed into the centre: holes drilled at intervals along the arm enable the point of a stencilling pen to be pushed through to the dial and circular arcs to be drawn. The radial calibrating marks are drawn along the edge of the arm at the appropriate angular settings. A pair of transverse arms, made of clear plastic, are fitted across the plate. These move freely up and down the plate and can be held in any position by means of a thumbscrew. A stencil is slid into the space between the arms and the legend and numerals are marked on the dial.

Heat-resistant inorganic polymers?

EVER since the *Sputnik* the achievements of Soviet scientists in all spheres have been watched with more than usual interest and some recent observations of A. Topchiev, vice-president of the U.S.S.R. Academy of Sciences, are worth recording. Speaking of immediate Soviet aims in the field of chemistry he anticipates a considerable emphasis on the study of polymerisation and said that interesting and important results in the field of petrochemical synthesis were expected. According to Topchiev, there is every reason to think that polymers would become one of the most powerful means of technical progress in the U.S.S.R. and that they may prove successful in spheres that now seem fantastic.

For instance, it is reported, Soviet chemists are close to developing chemically stable, purely inorganic polymers with plastic properties and the strength of ordinary organic polymers. ' It is not precluded ' that such substances will have so great a resistance to heat that they can be used instead of heat-resisting alloys.

Soviet chemists are also thinking about the manufacture of fabrics and garments directly from polymers, obviating spinning and weaving. Another tempting—or gruesome—prospect, depending on the way you think of it, is the synthesis of polymer systems possessing the properties of living albumen.

Titanium electrodes in chemical processes

THAT surprising metal, titanium, still pushing its way slowly but steadily into the chemical field, now appears in a new role—that of a material of construction for the anodes of chlorine/caustic cells. In fact, the Metals Division of Imperial Chemical Industries are ready to back it against graphite any day as the future material for brine electrolysis anodes. That is, so long as it carries a deposit of platinum, necessary because of the high electrical resistivity of the protective oxide film when titanium is used on its own.

I.C.I.'s confidence is based on recent investigations which indicate that titanium/platinum anodes offer considerable practical advantages over conventional electrode materials in various electrochemical processes. In chlorine/caustic production, it is claimed that the use of titanium will make it easier to maintain the all-important minimum gap between anode and cathode, close positioning of the two electrodes being possible without having to make provision for adjustment. It is also claimed that, since the oxygen overvoltage of platinum is even higher than that of graphite, production of oxygen-free chlorine will be readily permitted. Among other things titanium will do in brine electrolysis, it seems, is reduce chlorine overvoltage, so cutting electricity costs, and remove the source of possible contaminants.

This and other uses of titanium/platinum electrodes have been hinted at in previously published results of I.C.I. experiments, but not until now has the company given such a definite assurance of their promising future in electrolytic cells. Chlorine/caustic manufacture has been the chief target of investigations so far; tests are in progress to see how titanium/platinum anodes behave in cells producing inorganic oxidising agents, including sodium chlorate, sodium perchlorate, sodium perborate and persulphuric acid.

A further use for platinised titanium electrodes is seen in electrodialysis for producing fresh water from brackish or sea-water, in which it has hitherto been necessary to use different metals for the anode and the cathode. These electrodes tend to corrode and corrosion products may contaminate the membranes. Trials have now been made with platitinised titanium used for both anode and cathode, current being reversed periodically to facilitate removal of any deposits on the membranes. Because of their corrosion resistance, these show none of the disadvantages of other metal electrodes, and I.C.I. assure us that, by simplifying the operation of electrodialysis plant, such electrodes will help to extend the use of this type of de-salting equipment.

The production of sodium hypochlorite for sterilisation, electro-descaling, electro-galvanising, the industrial-scale separation of colloids by electrophoresis, and anodes for rhodium-plating baths are further interesting possibilities of platinised titanium.

Automatic neutralisation of effluent

FROM the German instrument firm of J. C. Eckardt A.G. come details of a system of effluent treatment at an industrial works, designation and whereabouts unspecified, where effluents of acid character, of *p*H 4.5 ± 1.5, are neutralised by treatment with ' dolomite milk,' a finely powdered double carbonate of calcium and magnesium, suspended in water. It is explained that dolomite milk is cheaper than caustic soda and produces less sludge than calcium carbonate alone.

The dolomite powder is added to water through a dosage screw conveyor, the mixing taking place in a mixing vessel. The dolomite milk passes to an agitating funnel where it meets the effluent water entering from a reservoir provided with a separator to remove oil, etc. The final mixture passes into a feed distributor in which the neutralisation reaction goes to completion, and thence to a settling unit, from which the neutralised effluent is run to a drain.

The automatic process is actuated by electrodes of *p*H recorders, acting through a 'P.I.D.' regulator system.

Stronger plastic pipe for industry

THE older British industries, it is said, generally turn a blind eye towards plastics. British Geon Ltd., a member of the Distillers Plastics Group, hope to counter this by taking energetic action to develop markets for its high-impact rigid PVC. Its main target will be pipe users in Britain, too many of whom, according to the company, reveal an inherent conservatism in their reluctance to specify piping of this sort.

For many years now the use of rigid PVC piping on the Continent has been widespread compared with

Britain. British manufacturers in many cases find an easier market for their product overseas—as, for instance, in the large liquid-handling installation of the Arab Potash Co. which has ordered five miles of 12-in. pipe for its works near the Dead Sea. In view of the poor response in Britain in the past, it was decided to postpone the attack on industry and pursue research until a new material of unquestionable suitability had been found. With the advent of a rigid PVC with an impact strength some 15 times greater than ordinary rigid PVC, manufacturers have started the conversion of pipe users with redoubled vigour.

The advantages claimed for the material are certainly well worth examining closely. Lightness (one-fifth the weight of iron and steel), ease of installation with no maintenance problems, resilience, non-corrodibility, insolubility and low resistance to flow are features attractive to most pipe users. Most progress has been made recently in the effluent pipe field and one example is illustrated elsewhere in this issue. The oil industry generally is well disposed towards plastics and the gas industry, though cautious because of the lethal nature of coal gas, is also responsive. It is expected that, when a six-month test period is completed, PVC piping will be fully approved for gas carrying.

Increasing interest is also being shown in it for the handling of paper slurries and many types of corrosive chemicals, and for use in locations where fumes cause external damage to metal pipes.

Chemical demineralisation of sea-water

THE search for the ideal solvent for separating fresh water from brine continues at the Agricultural and Mechanical College of Texas, U.S.A. It is proving to be no easy task to find a material which can dissolve water efficiently and not pick up salt or other foreign matter in the brine, and which also has such solubility relations with water that they separate when the solution is subsequently heated in the range of 140 to 175°F. This alone is not impossible to accomplish, but unfortunately there are a number of other necessary characteristics of a successful solvent for this process, such as low density, low viscosity, a moderately low boiling point, good selectivity against such materials as sodium, magnesium, calcium, and chloride and sulphate ions. The solvent should also be chemically inactive with water and not too alkaline. With too much alkalinity magnesium would precipitate out from sea-water and 'foul up' the process, as Dr. A. F. Isbell explained at a recent meeting of the American Chemical Society in San Antonio, Texas.

So tantalising has the problem proved so far that Dr. Isbell and his co-worker, Prof. D. W. Hood, are attempting to obtain a suitable solvent through chemical synthesis. Certain amines and ether compounds have been found promising and it is hoped to obtain the desired properties by a suitable combination of some of these.

Catalysts for tail-gas treatment

DURING the catalytic oxidation of ammonia to yield nitric acid considerable quantities of tail gases are produced, these consisting largely of nitrogen together with some oxygen and small quantities of nitrogen oxides. In the past it has been possible to discharge these noxious fumes directly to atmosphere. However, certain provisions of the Clean Air Act introduced in June 1958 will probably restrict this practice unless the effluent is pretreated to reduce the nitrogen oxide content.

The problem of cleaning up waste gases from nitrogen oxides is not easily solved by applying conventional methods such as scrubbing, absorbing in alkaline solutions, etc. A more efficient and economic line of approach has been found in the gaseous-phase treatment of the effluent over various catalysts designed to promote the reduction of the oxides to nitrogen by reaction with hydrogen or hydrocarbon fuels, or carbon monoxide.

Where hydrogen only is employed as the fuel, the nitrogen oxides are converted to nitrogen and water vapour; in cases where a hydrocarbon fuel is used, carbon dioxide is additionally produced, and occasionally some traces of carbon monoxide. In both cases the fuel is bled into the tail gas stream ahead of the catalytic converter and, dependent on fuel types, the temperature is raised to the requisite inlet level by means of heat exchangers. Oxygen present in the effluent will be reduced to water vapour for carbon dioxide along with the nitrogen oxides.

Additional to the production of a clean effluent, the above catalytic reactions are exothermic, giving rise to considerable yields of energy in the form of heat. This energy is very easily recovered from the effluent stream by a conventional turbo-expander before discharging to atmosphere.

Present trends in reactor design favour a two-stage process; the first stage is operated under oxidising conditions and it is here that the relatively high oxygen content of the normal raw tail gas is reduced to a level in the order of 1 to 2% by reaction with a calculated deficiency of fuel. After passage through an inter-stage heat exchanger a slight excess of fuel is added to the stream before it enters the second catalytic reactor. In this converter reducing conditions obtain leading to almost complete reduction of the nitrogen oxides together with the balance of the oxygen. The useful heat energy derived from these reactions is subsequently recovered in the turbo-expander; the inter-stage coolers normally take the form of waste heat boilers.

We learn about this development from the Baker Platinum Division of Engelhard Industries Ltd., who point out that a further aspect of this process lies in the very large quantity of relatively high-grade nitrogen produced by the catalytic conversion if hydrogen is used as fuel. It would appear that a case could be made, on economic grounds, for considering the recovery and purification of the nitrogen in the final effluent possibly for subsequent recycle to ammonia synthesis.

MIXING

Modern mixing machinery, from the largest industrial mixer to the smallest laboratory stirrer, represents an outstanding contribution of chemical engineering to the efficiency of industry today. In the following pages we present four articles covering various aspects of this widely used operation.

Progress Report on Agitation

By D. F. Riley, B.Sc., A.C.G.I.

DURING the last two years,* research in the field of mixing has generally followed established lines. There are papers on the usual topics, such as gas absorption in agitated vessels, the suspension of solid particles, liquid-liquid extraction, and the mixing of solids. Another paper fills a gap in our knowledge of the power consumption of impellers, dealing as it does with the effect of operating closed vessels completely full of liquid. New ground is also broken by a group of authors who have studied the agitation of suspensions which show non-Newtonian flow characteristics. These last may lead, in due course, to a systematic study of the mechanics of paste mixing, a branch of the subject on which practically nothing has yet been published.

Power consumption

Laity and Treybal[1] have compared the dynamics of agitating single and two-phase liquid mixtures in the absence of an air-liquid interface with that of agitating the same systems in open tanks. Vessels 12 in. and 18 in. diam. were used, with 4-in. and 6-in.-diam. flat-bladed turbine impellers respectively, and water was mixed with various organic liquids. While elimination of the interface has negligible effect on the agitation of a baffled vessel, it has a profound effect on the flow pattern in an unbaffled one.

For turbulent flow in an open unbaffled tank the power number is a function of both the Reynolds and the Froude numbers. If, however, the tank is covered and is operated completely full there is no vortex, although there is still swirling. Hence it is found that the power number under such conditions is independent of the Froude number, as is the case for a baffled tank, whether open or closed. It follows that pilot-scale data on agitation in unbaffled tanks can be scaled up provided the vessels are operated completely full. Over the range $Re = 10^3$ to 10^5 the results are expressed by the equation

$$\left(\frac{P}{\rho N^3 D^5}\right) = 14.86\ Re^{-0.25}$$

where the group on the left hand is the power number, Re = Reynolds number $\left(\frac{D^2 N \rho}{\mu}\right)$, P = power consumption, ρ = liquid density, N = impeller speed and μ = liquid viscosity, all variables being expressed in consistent units.

For calculating the Reynolds number of two-phase liquids special relations were developed for the effective 'mean' viscosity. Continuous flow only affected the power consumption at very high flow rates and for normal residence times it was concluded that the effect could be ignored. In two-phase systems the position of the impeller was varied and it was generally found that the continuous phase was that in which the impeller would be at rest. However, if the impeller was moved to cut the liquid interface then oil/water systems produced a continuous water phase, whereas in kerosene/water systems the organic phase was continuous.

A C.P.E. Chemical Engineering Review, revealing new advances in overcoming problems that are met with in the design of agitation equipment.

Gas absorption and liquid-liquid extraction

The data available on the effect of agitation on oxygen absorption in agitated tanks have been extended by Friedman and Lightfoot[2] to cover the use of four-bladed, open-paddle or turbine impellers. A copper-catalysed sodium sulphite solution was used in a 6-in.-diam. fully baffled tank provided with a cooling coil and an air sparger. A series of geometrically similar four-bladed paddle impellers was tested, varying from 1.19 to 3 in. diam., the blade height being in each case one-tenth of the paddle diameter. The speed was varied over the range 300 to 2,000 r.p.m. and the superficial air velocity 9.5 to 86.6 ft./hr.

Over much of the range the volumetric oxygen absorption rate was found to be independent of the gas velocity but directly proportional to the power consumption. Only at very low power inputs was the absorption rate affected by the gas velocity. On increasing the air flow rate the power input per unit volume at a given speed decreased and became constant above a rate of 45 cu.ft./hr. Comparison was made with the performance of a vaned disc impeller under approximately the same conditions. In general these runs showed that the vaned disc produced larger bubbles and used more power. At low speeds and low air rates the four-bladed paddle gave a more uniform bubble distribution,

**The author's last review of this subject appeared in our July 1957 issue.*

but at high speeds and air rates there was nothing to choose between them. High air rates and low impeller speeds produced larger bubbles from both types of impeller. When the smallest size paddle was used at low speeds poor bubble distribution resulted and the 'flooding' condition was easily reached.

On plotting the mass transfer coefficient against the power input factor (N^3D^5) a critical point was observed above which the coefficient was nearly directly proportional to the power input and below which it depended also very much on the gas rate. The conclusion drawn from this work by the authors was that gas flow had no effect when the impeller diameter was more than 40% of the tank diameter. It would be safer to conclude that the gas flow has no effect on the mass transfer provided the power input is sufficient, whether this is obtained from a large impeller at moderate speed or from a smaller impeller (<40% of tank diam.) at a correspondingly higher speed, the controlling factor from a design point of view being the mass transfer per unit power per unit volume.

By means of an elegant light scattering technique Calderbank[3] has measured the interfacial area in gas liquid contacting and has presented correlations of area with power consumption. Two cylindrical, flat-bottomed tanks were used, of 5 l. and 100 l. capacity, fully baffled and agitated by a single flat-blade turbine one-third of the tank width in diam. Air was introduced into each tank through a sparger situated centrally under the impeller, the bubble sizes being in the range 2 to 5-mm. diam. Ten different liquids were used, giving a fairly wide range of values for surface tension and other physical properties. The impeller was placed one diameter from the bottom of the tank and the liquid depth was about equal to the tank diameter.

The distribution of interfacial area was explored both radially and vertically and extreme variations were found. Simultaneous measurements of the power consumption and the interfacial area were made and were correlated by the equation

$$a = 1.44 \frac{P^{0.4}\rho^{0.2}}{\sigma^{0.6}} \sqrt{\frac{u_s}{u_t}}$$

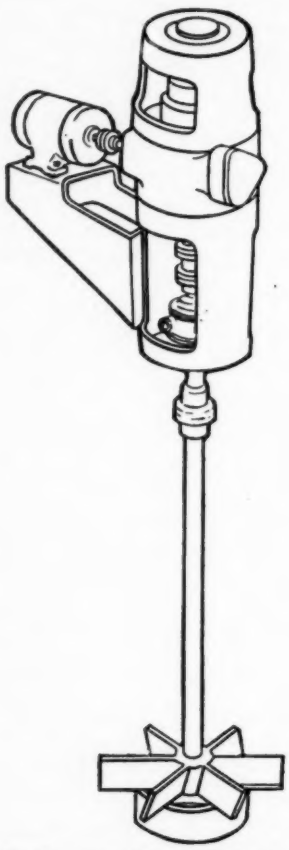
in which a = interfacial area per unit volume, P = power per unit volume, ρ = density of the continuous phase, σ = interfacial tension, u_s = superficial gas velocity and u_t = terminal gas bubble velocity, all units being in the c.g.s. system. This equation is valid in the range

$$\mathrm{Re}^{0.7}\left(\frac{dN}{u_s}\right)^{0.3} < 2.10^4$$

where Re = impeller Reynolds number, d = gas bubble diameter and N = impeller speed; a modified correlation being given for values $>2.10^4$. A relation is deduced for the gas holdup at high power inputs which agrees well with the earlier work of Foust, Mack and Rushton. The effect of solutes in hindering the coalescence of gas bubbles is discussed.

Measurements were also made of the interfacial area in liquid-liquid dispersions in the same equipment and more reproducible results than earlier workers were able to report were obtained by using hard water instead of distilled water as the continuous phase. By this simple device the troublesome effects of trace impurities were 'swamped out.' The drop sizes obtained in the aqueous dispersions of organic liquids were of the same order of size as that of the gas bubbles produced in the same equipment under the same physical conditions provided a solute was present to inhibit the coalescence of bubbles. In the absence of such a solute, bubble sizes are many times greater than the corresponding liquid droplet sizes.

Treybal[4] has analysed the data available on solvent extraction in continuously operated fully baffled vessels using flat-blade turbine agitators. He has attempted to obtain a method for calculating stage efficiency, but in view of the many assumptions made and the serious gaps in the data the results can only be regarded as the very roughest of approximations.

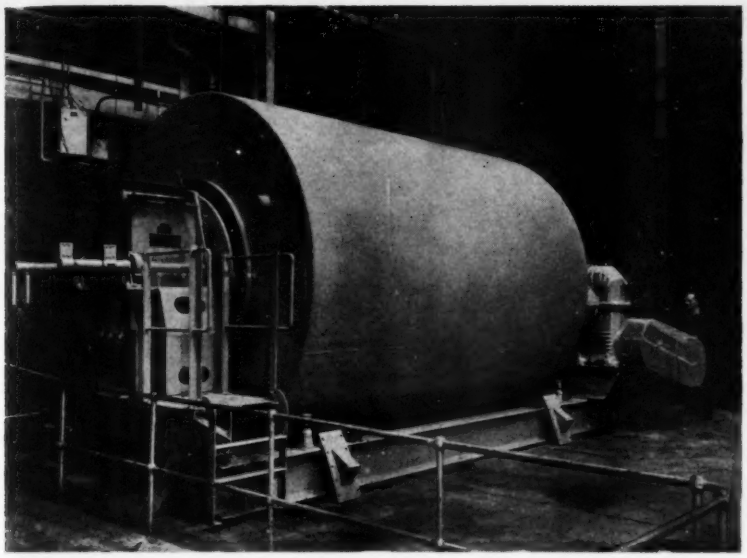


Diagrammatic view of the 'MajorMix' heavy-duty agitator developed by L. A. Mitchell Ltd. The main feature of the machine is the wide bearing spacing between top and bottom drive head bearings. Instead of the orthodox assembly of motor, gearbox and supporting stool, the gearbox output shaft is made hollow so that the agitator shaft itself passes right through this component into the upper stool of the machine. The bearing spacing is, therefore, approximately twice the normal spacing and this increases the stability of the complete unit.

The hollow gearbox output shaft is connected to the agitator shaft in the upper supporting stool by means of a special flexible coupling and, as a result of this, the motor and gearbox are isolated from the effects of any abnormal strain imposed on the agitator gear. The gear unit is provided with an external change speed box, in which pick-off gears can be arranged to give speed variations between 20 and 460 r.p.m. Change of speed is effected in a matter of minutes.

Below the gearbox in the main supporting stool accommodation is made for a robust bottom bearing housing in the case of open-top vessels and, for pressure or vacuum, either a mechanical seal housing or a gland assembly can be fitted. At any time a sealing device can be substituted for the bearing housing so that the machine can be adapted at very short notice to meet totally different process conditions. This feature of interchangeability is extended to the motor mounting arrangements, the motor bracket being capable of accommodating any of a wide range of motors to suit the individual mixing requirements.

Provision is made for servicing and possible seal failures, etc., by the design of the bottom stool which allows the mechanical seal housing to be removed in its entirety as a cartridge assembly without the necessity for dismantling the entire drive head. A spacer-type coupling above the seal housing is removed and this allows the seal housing to be lifted clear. After this operation the seals can either be replaced on the bench and the housing replaced or a completely interchangeable seal housing can be substituted with a minimum break in process time.



One of the largest powder-blending machines ever to be made in the United Kingdom, seen here at the works of the Sturtevant Engineering Co., who designed and manufactured the unit. It is destined for the new 'Acrilan' factory being built in Northern Ireland by Constructors John Brown Ltd., where its purpose will be to obtain a homogeneous blend of very fine polymer powders.

The unit is approximately 25 ft. long overall, 13 ft. high and 12 ft. wide. It has an uncharged weight of some 17 tons, and is capable of blending single batches of up to 450 cu. ft. in volume.

The shell and all material contact surfaces are lined in corrosion-resistant material, and the entire machine is arranged for internal purging with inert gas. The intake and discharge box forms a unit at one end of the machine, the charging and discharging mechanism being motorised for remote control.

The highly efficient action of the unit is obtained by both a cascade and lateral movement of the material, the lateral distribution being obtained by pivoted chute plates fitted with differential linkages.

Suspension of solids

Problems in the scaling-up of the design of liquid-solid reactors have been discussed in a paper by van de Vusse.[5] He considered the requirements for just keeping all particles in suspension under conditions of isotropic and non-isotropic turbulence. For the former conditions, as in a vertical stirred tube reactor with multiple impellers such as the rotating disc contactor, it is deduced that the criterion for scaling-up is the dimensionless group

$$\left(\frac{D^2N}{uh}\right)$$

where D = impeller diameter, N = impeller speed, u = particle settling velocity minus liquid velocity, and h = height of bed that would exist if all the particles were settled to the bottom of the reactor.

Where the turbulent field is non-isotropic, as in vessels with a single impeller small in relation to the tank diameter, the hydrodynamic conditions are quite different and are, in fact, too complex to be analysed in the same way. In such cases the criterion for scaling-up is obtained empirically and is the dimensionless group

$$\left(\frac{P}{ug\ \triangle\rho\sqrt{V_d.V_c}}\right)$$

in which P = power consumption, $\triangle\rho$ = particle density minus liquid density, g = acceleration due to gravity and V_d, V_c are the volumes of the dispersed and continuous phases respectively.

Humphrey and van Ness[6] have determined mass transfer coefficients when dissolving sodium thiosulphate crystals in water in an agitated vessel. The tank was 12 in. diam., fully baffled, and was agitated either by a 4-in. propeller or by a 4-in. flat-blade turbine. In order to avoid the difficulties resulting from the unsteady-state conditions of a batch reaction the crystals and water were fed continuously to the vessel and the solution was drawn off continuously through a conductivity cell. The mass transfer coefficients were correlated by means of the usual form of equation developed by Hixson and Baum (1941) and the values for the exponent of Reynolds number obtained were 0.58 for the propeller and 0.87 for the turbine.

The design requirements for a batch agitator suspending solid particles in a liquid of low viscosity have been studied by Zwietering[7] and empirical correlations are given for simple cases. The distribution of particles through the liquid was not investigated, the lifting of all particles from the bottom of the vessel being taken as the criterion of adequate agitation. Fully baffled vessels of 3 to 170 l. capacity were used, with four different types of impeller and two solids, which were suspended in five liquids. The concentration of the slurries varied up to 20% by weight. Kneule had already shown that it is often uneconomic to increase the agitator speed beyond that needed to just suspend all the particles, since above that speed the mass transfer rate increases only very slowly. Unfortunately, as geometrical similarity was not maintained, the equation given in the paper cannot reliably be used for scaling-up. Further, although it is stated that the experiments were confined to fully baffled vessels and Re exceeded 3,000, the Froude number raised to the power 0.45 appears surprisingly in the correlation. It was found that particles $<200\mu$ in size formed a fairly homogeneous suspension when completely lifted off the bottom of the tank, whereas, under the conditions of the experiments, particles larger than 800μ did not reach the upper layer of liquid.

Non-Newtonian liquids

Very little work has been carried out as yet on the agitation of liquids which show non-Newtonian flow characteristics such as are commonly met with in the chemistry of high polymers. Since the viscosity of such materials is a function of the shear stress applied it will vary not only with the agitator speed but also with the location of the point in the mixing vessel under consideration. A viscosity gradient is set up in the liquid, resulting in imperfect mixing, poor heat and mass transfer, which may lead in turn to inadequate control of a polymerisation process.

Metzner and Otto[8] determined power characteristic curves for three non-Newtonian liquids in tanks of 6 to 22 in. diam. with flat-blade turbine impellers of 2 to 8 in. diam. The materials tested were suspensions of clay and of sodium carboxymethylcellulose, and all showed pseudoplastic behaviour in which the apparent viscosity (*i.e.* the slope of the shear stress/shear rate curve) decreases as the shear

rate increases. Most of the experimental data were in the laminar or transition regions of flow and it was found that they conformed to the same general pattern as is shown by Newtonian liquids, with the exception that the laminar flow region extended to rather higher values of the Reynolds number.

Lee, Finch and Wooledge[9] have determined power characteristics for a number of solutions of polystyrene in ethylbenzene, using flat-blade turbines in tanks 6 to 22-in. diam., both baffled and unbaffled. They observed that the polymer solutions behaved as Newtonian liquids at low shear stresses, but showed non-Newtonian characteristics at high shear stresses. Experiments were also conducted with high-viscosity Newtonian liquids.

A 6-in.-diam. shrouded turbine was found to require 50% more power at the same value of Re, in the streamline region, than an unshrouded turbine in the same baffled tank. Rates of mixing in the transition region of flow were obtained by measuring the time taken for a soluble dye to be dispersed completely throughout the contents of the vessel. In an unbaffled tank at a given value of Re, mixing was considerably more rapid for the open than for the shrouded impeller, as had been found by earlier workers. The rate of mixing increased slowly with the value of Re until a critical point was reached (about Re = 45 for the open, 85 for the shrouded impeller) when it increased very rapidly. In a baffled tank, however, using dual open impellers there was no critical number for Re, the mixing rate increasing steadily with the Reynolds number. The last region to be mixed was that in the vicinity of the baffles, which were placed $\frac{1}{8}$-in. away from the vessel wall.

The mechanism of mixing in streamline flow systems is discussed by Mohr, Saxton and Jepson.[10] The criteria for determination of degree of mixing suggested by Danckwerts, namely scale of segregation and intensity of segregation, are discussed and it is concluded that the mechanism by which the scale of segregation is reduced in highly viscous liquids is that of shear strain. The components are drawn out by shearing action into progressively thinner striations and a theoretical equation is developed for the striation thickness in terms of the amount of shear strain imposed. In a subsequent paper the theory is applied to predicting the effect of variables such as helix angle and depth of thread on the performance of a single-screw extruder.

Mixing of dry powders

Agitation in a helical-ribbon, U-trough mixer of 6 cu.ft. working capacity has been studied by Greathead and Simmonds.[11] One pound of magnesium sulphate was added to 199 lb. of sodium bicarbonate of known bulk density and particle size distribution and samples were withdrawn at prescribed intervals of time. Runs were made to determine the best point of addition of the magnesium sulphate and it was found that satisfactory results were only obtained when the addition was made on the side of the trough in which the agitator blades descended into the powder.

Increasing the charge to 300 lb. or decreasing the speed from 60 to 28 r.p.m. had no effect on the mixing performance but reducing the charge to 100 lb. or increasing the speed to 85 r.p.m. gave erratic results. Mixing was found to be about eight times as fast in the surface layers, where resistance to movement is least, as in the bulk of the batch. The mechanism of the mixing and segregating action of the blades was analysed and suggestions were made for modifying the blade section to reduce the segregating tendency. In a separate experiment it was found that there was a progressive deterioration in the quality of a mixture as it passed from a large vacuum rotary drier/mixer through a conveying and elevating system to storage.

Rose[12] has presented an equation expressing the degree of mixing of two solids in terms of assumed relations for the rates of mixing and segregation. The equation was fitted to the data of Coulson and Maitra (1950) for an inclined drum mixer and the values of the coefficients expressing the rates of mixing and segregation were related to the physical characteristics of the mixer and of the powders being handled.

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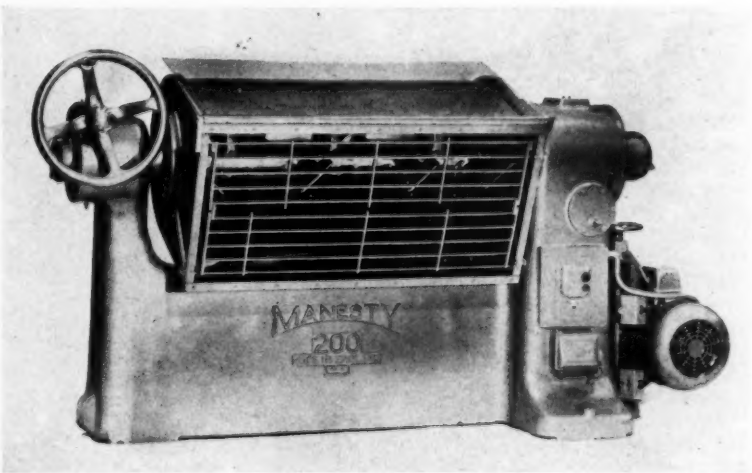


This new machine by Manesty Machines Ltd. has been designed for the intimate mixing of powders or moist masses and, with a capacity of about 200 lb., is especially suitable for preparation of tablet granulations. The paddle is driven by a 'Holroyd' gear drive and the mixer is stated to be ideal for handling sticky ingredients. The design of the cabinet permits the positioning of suitable trays or receptacles directly underneath the container for direct unloading when the container is tilted. The paddle-mounting sleeves are retractable and the paddle can be removed from the chamber for cleaning.

The drive from the motor is through a vee-belt on to the totally enclosed worm and wheel. The wheel shaft carries a special retractable driver connecting with the paddle; the design of this driver ensures a positive drive and prevents the ingress of material on to the paddle mounting.

MIXING MACHINERY

NEW PRACTICAL AIDS TO EFFICIENT PROCESSING

Mixing in the pipeline

A new unit by Wm. Boulton Ltd. mixes fluids as they pass through a pipe. Available in sizes from 1-in. to 6-in. bore, it can be made in cast iron, stainless steel or the usual constructional metals. The straight-through design of the *Thrumix* enables it to be inserted in a pipeline without the need for bends or tees.

The principle employed is a shear of very high degree and a controllable degree of recirculation, power being supplied by a motor of from $\frac{1}{3}$ to 2 h.p. Either a standard stuffing-box or a mechanical seal is fitted. On low-viscosity materials the throughput is approximately 14 gal./min., increasing to a maximum of 400 gal./min.

It is claimed that anything that can be pumped will pass through the mixer and that, owing to its simplicity, it is ideal for use in continuous processes where an agitating tank is at a disadvantage. Applications include the combining of liquids, liquids and gases, or liquids and solids; the aeration of liquids and gas absorption; the mixing of flocculation agents for thickening; and sludge conditioning. Two models are being produced, one with a fixed degree of recirculation and shear and the other with means for axial movement of the stator cage.

Side-entry mixers

Side-entry propeller mixers introduced by Plenty & Son Ltd. incorporate several new features, including a mechanical seal as standard. The mechanical seal and all other components can be quickly replaced or repaired without having to drain the tank. Maintenance on the clamping and sealing device is all carried out from the outside of the tank.

A range of mixers is available with prime-movers from 10 to 25 h.p.

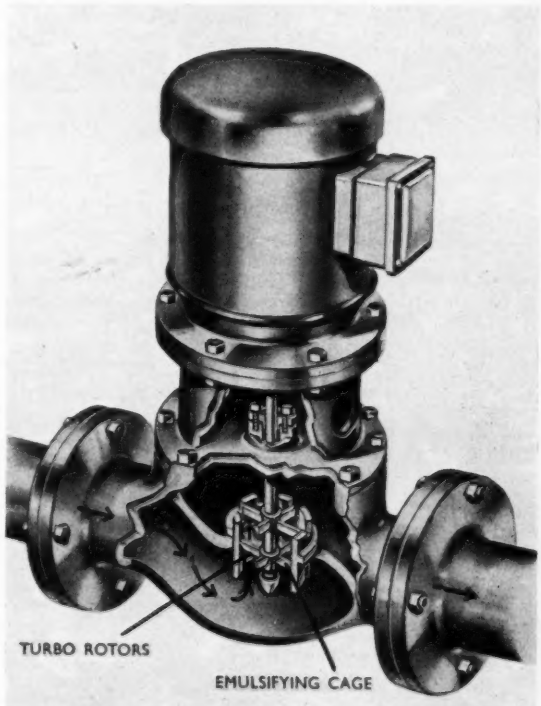
High-viscosity mixer

The Moritz *Turbo-Cleaver* has been designed to make use of an impeller even when very viscous products are to be handled in mixing, homogenising and dissolving. The impeller used in this machine has specially designed cutting vanes and an outer stationary crown which acts not only as a baffle but increases the cutting action of the blades. The impeller is large in diameter and bears close relation to the diameter of the vessel in order that it may operate without cavitation in very viscous media.

The vessel is provided with bottom-entry drive, leaving the top of the vessel free. The impeller shaft and gland are adjusted on the upward shaft extension of a reduction gear unit, the latter forming the base supporting the vessel. As the gland is mounted on a machined flange centred in relation to the impeller, a perfect alignment is assured.

The section of the shaft passing through the gland is chromium plated and polished.

A high-speed portable turbo-reactor developed by the



Cut-away view of Wm. Boulton's 'Thrumix' device.

same company, Moritz Chemical Engineering Co. Ltd., may be provided with single, two-speed or three-speed motor. Running at its top speed of 3,000 r.p.m., it creates violent circulation in the vessel and any given quantity of product quickly passes a considerable number of times through the outer crown. This machine is particularly suited for the preparation of products in which solids are to be dispersed in liquid or fluid mediums.

Clamp-mounted mixing device

A smaller and more streamlined version of the *Universal Mixer* of Premier Colloid Mills Ltd. has been developed with a motor of up to 1 h.p. Direct-drive motors of 1,500 r.p.m. are possible and a specially designed gearbox can be incorporated to give very slow mixing speeds. The new unit is generally similar to the *Universal Mixer*, which has for a mixing head a *Dispersator* of 3-in. diam. in stainless steel, or three-bladed, marine-type polished and balanced stainless-steel propellers of various diameter and pitch according to the requirement. The shaft is 1-in. diam. 18/8 stainless steel made to the required length, and the mounting is by a rigid twin-clamp fixing, swivelled to allow positioning of the mixing head.

Another forthcoming development announced by Premier Colloid is a small, laboratory-sized, heavy-duty mixer with a high torque for the mixing of pastes.

Heating pans with agitation

Electrically heated tilting pans being offered by the Stabilag Co. Ltd. are portable with no permanent connections. Temperature gauges are easily accessible and controls enable the heat input to be adjusted. Mixers or agitators can be used temporarily—or permanently where mixing is always required through the whole heating operation—and can be operated from the control panel which is an integral part of the unit.

The pan is single-cased, allowing access to the inside of the jacket for essential cleaning and maintenance.

Cube-shaped mixers

The problem of obtaining an accurate mix with widely varying ingredients is answered by *Rotocube* dry powder mixing machines, it is claimed. Developed by Foster, Yates & Thom Ltd., they comprise a cube-shaped drum mounted diagonally at a compound angle on trunnions and rotated at 10 r.p.m. The resulting action prevents the heavier ingredients from accumulating and effects uniform distribution of even the ingredients present in the smallest percentage.

Impellers can be introduced which combine an overturning motion with the interweaving action. Discharge is by a valve in the lowest corner or by 'inching' the drum into position where two of its sides form a chute.

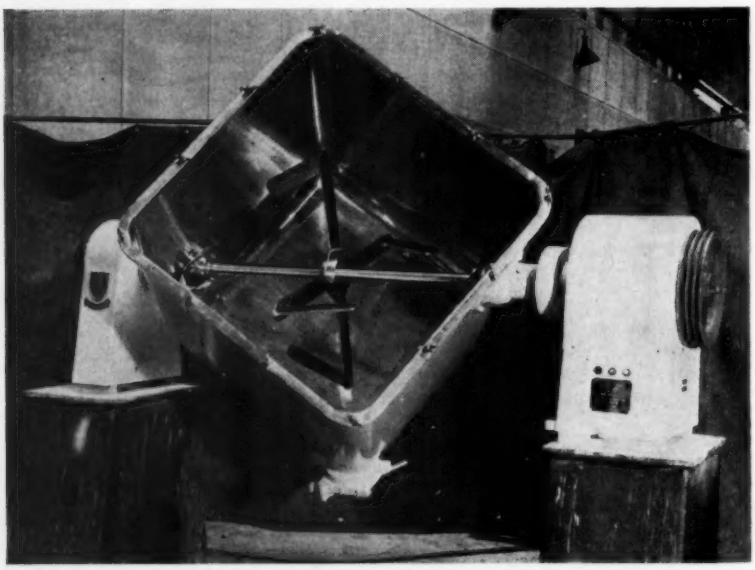
The main drive is by a low-h.p. electric motor driving an 80 : 1 heliocentric reduction gear to which the drum is attached by half-couplings. A process timer can be incorporated and the starter unit includes an 'inching' control. Production or laboratory models range in charging capacity from 10 to 1,600 lb., with drums and impellers of mild steel, stainless steel or aluminium, and can be in transportable form or for fixing to foundation columns.

Grinds as it mixes

The *Atritor* drier-pulveriser, although not initially a mixing machine, can be used for this purpose. Where grinding of the material is also desirable it is necessary for the materials to be rough-mixed or blended prior to feeding into the machine, but, once inside, even and very intimate mixing occurs.

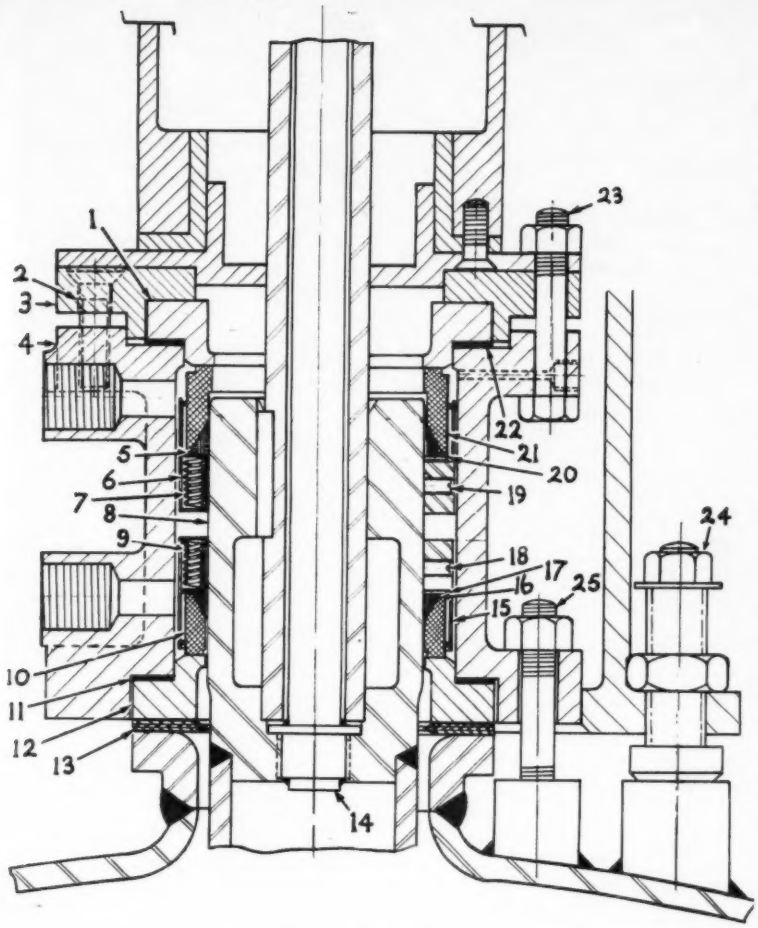
This is due to the fact that the *Atritor* is an air-swept mill and the particles are therefore in suspension in the air stream, furthermore, in one section of the machine very turbulent air conditions occur (this incidentally helps the grinding in that the particles are rubbed together, *i.e.* grinding is carried out by the attrition process), thus intimate mixing of different materials is possible.

The makers of the machine, Alfred Herbert Ltd., report

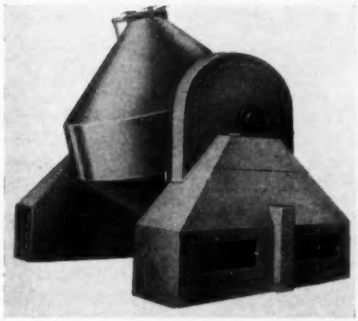


'Rotocube' mixer by Foster, Yates & Thom.

A 'Universal Mixer' by Premier Colloid Mills, with a twin clamp for fixing to a vessel.



Mechanical seals of the type shown in the diagram are offered by Enamelled Metal Products Ltd. for use on the agitators of Pfaudler reaction vessels in place of standard stuffing boxes. Components are: (1) and (12) stationary seat (Stellited), (2) countersunk head set-screws, (3) 'SW' clamp plate, (4) 'SW' seal housing, (5) and (16) wedge ring, (6) and (15) spring case, (7) and (9) spring, (8) agitator end, (10) and (21) stationary seal ring, (11) and (22) joint, (13) envelope joint, (14) draw shaft, (17) and (20) metal disc, (18) and (19) driving grub screw, (23) H.R.H. bolts, (24) adjusting screws, (25) studs.



This 14-ft. double-cone mixer for the plastics industry weighs over 28 tons and is thought to be the largest of its kind ever made. It is of stainless steel and is manufactured by Wm. Gardner & Sons (Gloucester) Ltd. The double-cone type of mixer combines simplicity and anti-attrition properties and is used for the mixing of powders, dyes, resins, pharmaceuticals and food products.

that it has been used successfully to mix together such material as fire clay and grog (broken tile waste) for the manufacture of firebricks; another example is the mixing together of resin and hexamine in the plastics industry, while another is the mixing of 11 different materials which were the constituents of a coloured, waterproof, cement-type paint.

Mixer and heat exchanger

The *Flowmaster* reactor of Baker Perkins Ltd. is essentially a continuous mixing and blending unit for fluids, waxes and light doughs, which, whilst mixing or blending, may transfer heat to or from the material being processed.

It consists of a series of fixed heat-transfer plates through which a heat-transfer fluid, *e.g.* brine, water, steam, heat-transfer oil, *Dowtherm*, etc., may be circulated. Spaced between each heat-transfer plate are beaters mounted on a common shaft. These beaters intensively mix in a relatively small volume the material flowing through the channels of each heat-transfer plate. The turbulence creates a thin film giving high heat-transfer coefficients and, owing to the heat-transfer plates being scraped by the beaters, there is little chance for a degrading film of material to be formed.

Three standard-size heat-transfer plates are available, of 7, 11 and 18 in. diam., whilst larger sizes are being considered. Where necessary, two, three or more reactor assemblies may be mounted on one base frame and driven by one motor. Only one product seal is required and that for the beater shaft. Stuffing-box-type glands of adequate size are interchangeable with mechanical seal assemblies.

In models operating at pressures up to 350 p.s.i.g. there are no gaskets or jointing compounds required but those models operating at higher pressure or extremely fluctuating temperature conditions have simple seals which in most cases are reusable. Construction is of stainless steel but any normal material may be used if required. Operating temperature ranges from 32 to 400°F. and heat-transfer plate operating pressure is 100 p.s.i.g. steam. Special machines are available for operation at pressures up to 1,000 p.s.i.g. and temperatures up to 750°F.

Mixing plastics and resins

The mixing of thermoplastic materials and formulations at the Dow Chemical Co., Midland, Michigan, U.S.A., is being accomplished through the use of a special horizontal batch mixer, of which all metal parts in contact with the material are manufactured from nickel. The mixer, supplied by Sprout-Waldron & Co. Inc., has a swept volume capacity of approximately 58 cu. ft., is designed to handle a 3,000-lb. batch and has an extra-heavy reinforced U trough and cover. It is jacketed for 30 p.s.i.g. liquid

working pressure and contains internal baffles to prevent short-circuiting. Mixing action is by a double-ribbon agitator with end stubs set in anti-friction pillow blocks.

Another special Sprout-Waldron unit is a stainless-steel 50-cu. ft. vertical mixer for polycarbonate resin moulding compound at the General Electric Co. It is 10 ft. $10\frac{3}{8}$ in. high, 10 in. in diam. and is jacketed for 14.7 p.s.i.g. steam pressure. The product has to be blended while in $\frac{1}{8}$-in. chopped rod pellet form just prior to packaging.

The mixer is supported by four vertical legs attached to the sides of the cylinder and the overall space requirement, including the table-height hopper unit is less than 15 sq. ft. The forced feed-in screw and elevating section below the mixing cone are aimed at giving maximum efficiency.

Y-cone blenders

A recent development in powder mixing is the Apex Y-cone blender, of which some details were given in our October issue, page 370. The smallest of the models, which have working capacities of 4 and 8 quarts, are made in *Perspex* and so are particularly suitable for observing the mixing action. An agitator bar can be fitted and its use is recommended where materials tend to 'ball up,' where flocs have to be dispersed, when using materials of different particle size, and also in the dispersion of liquids in solids.

The agitator bar consists of a bar of stainless steel carrying a number of pins and is driven through hollow trunnions by a separate motor. It is easily removed by a sping-loaded mechanism for cleaning and for use of the mixer without the bar. Apex Construction Ltd. make these Y-cone blenders.

Epicycle movement

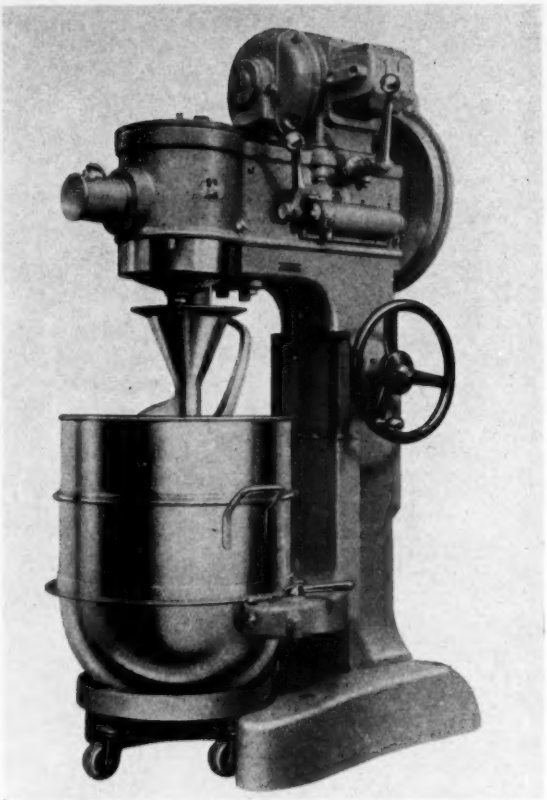
Planetary action with an epicycle movement is employed in the *Hobart* mixer. The standard bowls are one-piece pressings of heavy-gauge steel, heavily tinned, and capacities range from 100 to 5 quarts, while motors vary from 2 to $\frac{1}{8}$ h.p. The largest mixer, the ME800, has a 4-speed, selective, sliding-gear-type transmission, with hardened gears running in oil, and speeds of 56, 98, 181 and 323 r.p.m. are attained. Its weight is 1,480 lb. and standard colour, grey.

Model SE500, with 50-, 30- and 20-qt. bowls, runs off a 1-h.p. motor with speeds of 85, 155 and 262 r.p.m. and weighs 716 lb. This mixer, by Hobart Manufacturing Co. Ltd., is considered particularly suitable where batches of different quantities are required. The smallest of the range, CE100, is a bench model for laboratory use, with lubrication from grease packing alone, in common with other smaller models. Grinding, crumbling, crushing and sieving attachments are available as are *Isomantle* heaters.

Metering and mixing

Continuous metering and mixing of powders and like materials is achieved by *Alite* powder filling machines used in conjunction with a double-cone mixer. The system is for bulk powder ingredients to be fed at a set rate through the filling machines; this can be as little as 1 lb./hr. or over 100 lb./hr. A common cross-feed spiral conveyor is used, which, whilst carrying the materials to the double-cone mixer, also carries out a pre-mix or blend.

No baffles or blades are used normally in the double-cone



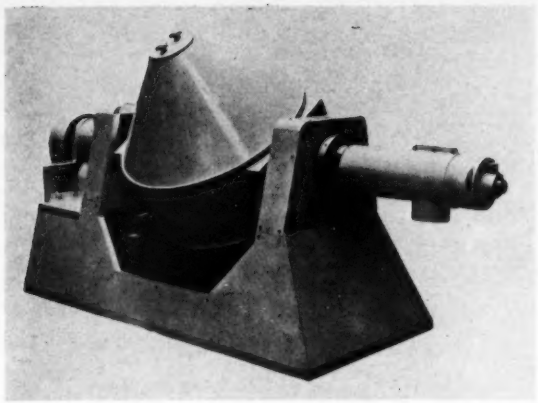
The largest of the 'Hobart' mixers, the ME800.

mixer so no damage by attrition or polarisation takes place. The input screw on the mixer extends to the inside and materials fed to it fall immediately into the rotating chamber. The shaft carries on right through to the outlet where the blades of the outlet screw are recessed inside the mixer and carry on through to the discharge outlet. The outer case of the outlet screw is totally enclosed from the outlet of the mixer body but is extended on the inside in the form of a trough, this being adjustable, to collect the correct amount of mixed material for subsequent discharge. Makers are Alite Machines Ltd.

Multi-purpose machine

A multi-purpose immersion mixer-emulsifier, available from Silverson Machines (Sales) Ltd., also homogenises, viscolises, pumps, filters and strains at speed. A new cutting attachment is available for rendering down solids, flake gums, and other materials. The machine consists basically of a powerful, centrifugal suction pump, enclosed in interchangeable heads. The rotor blades in the standard machines revolve at 2,800 r.p.m. and subjects liquids being mixed to an intense, high-velocity shearing action.

By changing the head of the mixer or inserting an emulsor screen the action of the stirrer can be modified. The standard head allows the mix to be sucked in at the bottom and projected in a horizontal plane at high velocity. This is used if the quantities of liquid are small or shallow in depth. An inward or outward circular mixing current



This double-cone mixer by Alite is used in conjunction with their powder-filling machines in a continuous metering and mixing system.

can be achieved by adjusting the position of the head.

The axial-flow head projects the liquid vertically up the shaft of the stirrer towards the surface of the mix, and circulates outwards and down the sides of the vessel. It is specially useful for mixing in a deep container and for preventing an insoluble powder from settling. The axial flow prevents vortex formation, with a subsequent entrapping of air.

With Silverson's high-speed immersion ball mill, materials are sucked into a working track where they are subjected to an intense pulverisation by stainless-steel balls and injected back into the mix as an impalpable and homogeneous suspension.

Outsize vertical mixer

The *Giant* vertical mixer, employing planetary action, has a bowl capacity of up to 65 imp. gal., weighs over 2 tons, is 10 ft. high and is produced to individual orders.

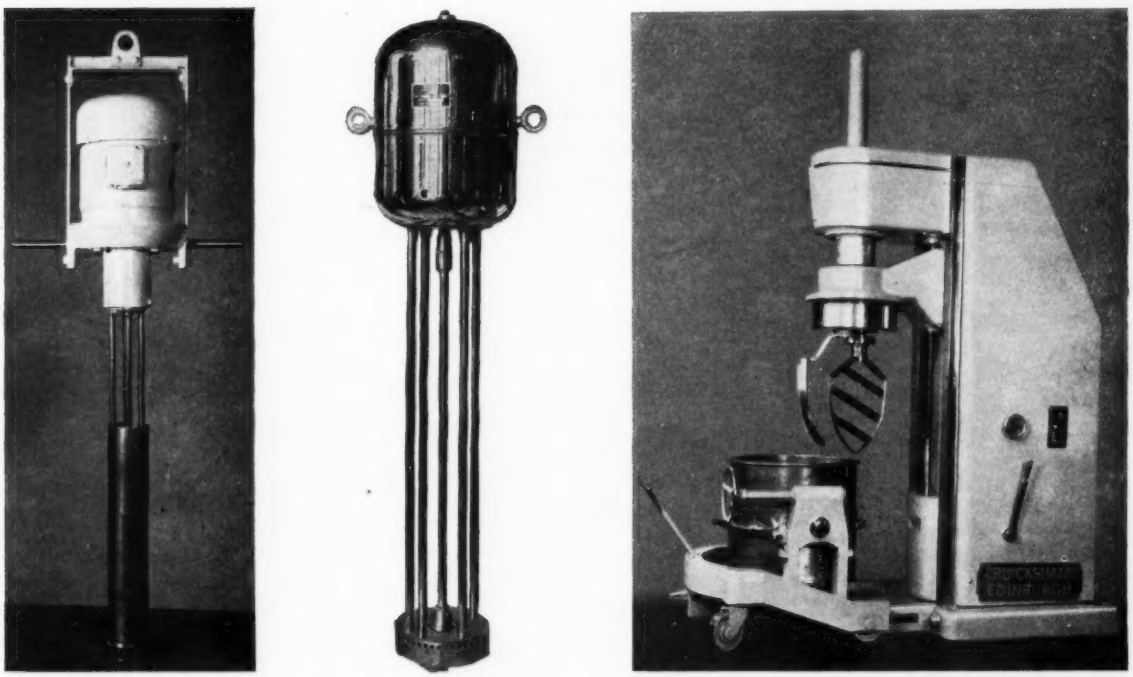
The main frame is a single fabrication of $\frac{1}{2}$-in. and thicker steel plate, while the fixed and moving gear heads are castings. Electric motors, control equipment and gearing are enclosed within the main column with servicing access through a large side door. Single or two-speed drive is available with pole-changing electric motor, or, for complete coverage, a 9 : 1 ratio variable-speed gear coupled directly to the motor. A separate motor raises and lowers the mixer and, like the main motor, is push-button controlled.

Mixing bowls in various metals or alloys are fully portable and tipping devices are available, as are different mixing appliances and bowl scrapers. Ointments, compounds, pastes, fluids, semi-fluids and dry powders can be mixed with this machine, supplied by James Cruickshank Ltd.

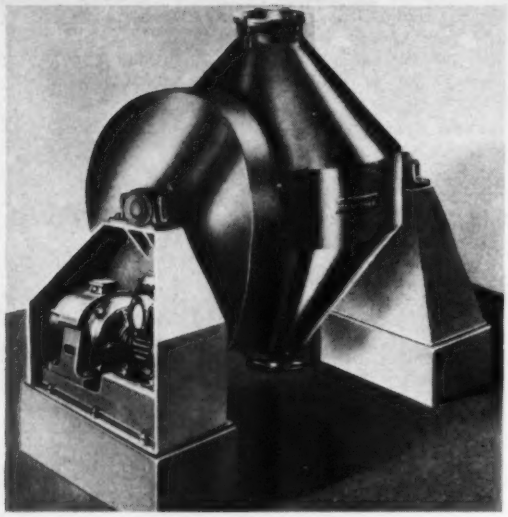
High-speed processing

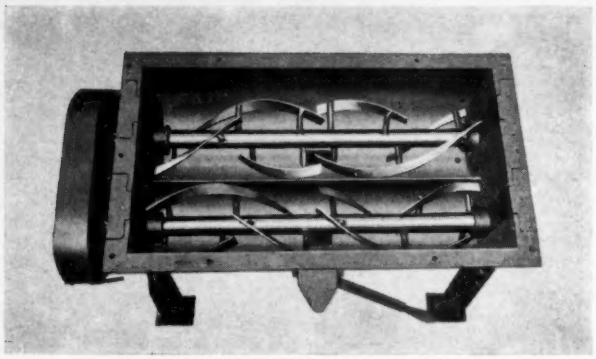
The *Ultramix*, by Vickers Ltd., is a portable, high-speed machine for the mixing of liquids, dispersion of solids in liquids, dissolutions, and acceleration of chemical reactions. Duties include pre-mixing, thinning, tinting and preparation of paints and varnish; ink toners; special resin products; adhesives; bitumen products; pharmaceuticals; confectionery; electrical cable coatings; automotive chemical products, including liquid polishes; and casting mould dressings.

The turbine, driven through a shaft directly coupled to



Three mixers shown here are (*left*) the portable 'Ultramix' by Vickers Ltd., (*centre*) a versatile mixer-emulsifier by Silversons, and (*right*) a 'Giant' mixer of James Cruickshank Ltd.





Above: **View of the J. Harrison-Carter double-worm mixer. If heating or cooling of the product is required during mixing, the trough can be steam- or water-jacketed.**

Left: **An 'Oblicone' mixer by Steele & Cowlishaw.**

the motor, is constructed with vanes of special design. It performs three distinct operations:

(1) An axial suction downward from the top of the vessel.
(2) An axial suction upward from the bottom of the vessel.
(3) Mixing the streams from the top and bottom, and expelling radially through the cage.

The cage encloses the turbine. As the vanes of the turbine force the material under pressure through the grid formed by the bars in the cage, shocks at high frequencies and intense shearing effects are created. On leaving the cage the material is subjected to turbulence which provides additional mixing.

Thorough circulation of the batch is ensured by a sleeve fitted outside the tie rods. This sleeve is made up of removable sections so the height of the intake above the turbine can be adjusted. The *Ultramix* is cleaned by running the machine in a suitable solvent. It is adaptable for suspension from overhead lifting gear, or for mobile or fixed mounting in a vessel. Impeller diam. size ranges from 2½ to 6½ in., motors range from ½ to 10 h.p. and standard shaft lengths from 18 to 48 in.

Shakers and blenders

Steele & Cowlishaw have introduced for the chemical and pharmaceutical manufacturing industries the *Quickway*, *Oblicone* and *Diamond* machines. The *Quickway*, a shaking machine, is suitable for mixing small quantities of powders and liquids in jars or containers clamped in the adjustable holder. It has a vigorous dual reciprocating oscillating motion with 1,400 agitations/min. Capacities, in the two models available, are for ¼ pint to 1 quart, and from 1 quart to 1 gal.

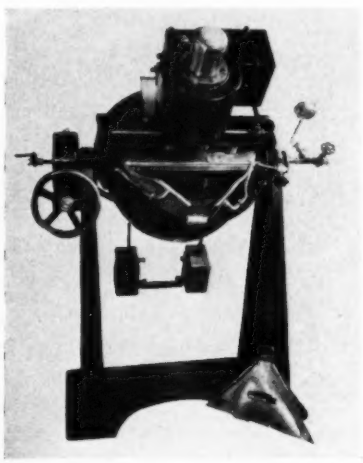
The other two machines are blenders for free-flowing solids ranging from fine powders to large pebbles. The obliquely set cones of the *Oblicone* impart a gyratory and tumbling motion at each spin of the drum. All particles follow a different trajectory resulting in a complete and uniform blend. The *Diamond* blender gives a different particle movement, the material being divided into twin streams which cascade into the lower half of the unit. A slow spiral movement around the four tubular members is achieved by diagonally setting the diamond. Both machines can be 'custom' made.

Double-worm mixer

A double-worm mixer for blending and mixing granular or powdered materials is available in black sheet or stainless steel and for certain processes can be either water- or steam-jacketed.

The machine, designed by J. Harrison-Carter, consists of two U-shaped troughs each of which has two ribbon-type scrolls mixing the ingredients in three directions along the whole length of the troughs. A differential prevents the two sets of scrolls from running at the same speed. This method gives a blend superior to that of the single trough mixer also made by the firm. This is useful for the simple mixing of granular and powdered materials and it can also be used for mixing in of liquids such as oil, spirit or water to the ingredients.

Various forms of rotating centres can be supplied, depending on the material to be dealt with and the operation required.



This stainless-steel, steam-jacketed pan has a welded joint and is fitted with special hydraulic-drive stirrer. The stirring arrangement continues to revolve as the pan is tilted so that mixing is taking place until the last moment. Makers are William Brierley, Collier & Hartley Ltd.

Testing Dry Solids Mixers

By H. Bannister, Ph.D., M.Sc., D.I.C., A.M.I.Chem.E.

In these notes the writer illustrates by example the value of tests in assessing the performance of a batch dry solids mixer.

MOST methods of testing the efficiency of dry solids mixers rely on statistical theory, the standard deviation[1] or some modification of it being the favourite measure of dispersion used.

One commonly applied formula is:

$$\sigma = \sqrt[2]{\frac{1}{N}\ \Sigma\ (\bar{x} \sim x)^2}$$

where σ is the measure of dispersion (S.D.), N is the number of samples taken, $\bar{x}$ is proportional to the *desired* concentration of *one* of the constituents and x is proportional to the *instantaneous* concentration of the same constituent.

In batch mixers, samples should be taken at fixed intervals of time at the same spot in the mixer during processing, whereas in a continuous mixer, once dynamic equilibrium has been achieved, time is not significant and samples should be withdrawn at points spaced equally along the length of the machine between the feed and discharge positions.

Mixer tests

The application of these principles is now illustrated by reference to tests on a mixer in a sand/lime plant. This was a batch machine of the ribbon or spiral-bladed type and the total alkalinity of the desired mix was such that 10.8 ml. of 5N hydrochloric acid was needed completely to neutralise 10 g. of sample. This weight was selected to suit the scale of scrutiny desired.

In the table, test run No. 1 shows the results of titrations on 10-g. samples withdrawn from the discharge opening every 3 min. during 1 hr. of mixing, and the upper curve in Fig. 1 shows the relationship between the standard deviation and the time measured from the start of mixing. If the equation of test 1 could be written down, mathematical differentiation could be applied, but to save this complication the angle of the curve α was measured at A.

The mixer was then opened and it

Tests on Batch Sand/Lime Mixer

($\bar{x}$ = 10.8 ml. of 5N HCl)

Run No.	Time after start (min.)	Test run No. 1			Test run No. 2		
		Ml. 5N HCl	$(x \sim x)^2$	$\sigma = \sqrt[2]{\frac{1}{N}\Sigma(\bar{x}\sim x)^2}$	Ml. 5N HCl	$(\bar{x} \sim x)^2$	$\sigma = \sqrt[2]{\frac{1}{N}\Sigma(\bar{x}\sim x)^2}$
1	3	51.3	1,640	40.4	10.1	0.49	0.7
2	6	47.2	1,324	38.4	47.3	1,331	25.8
3	9	3.1	59.2	38.8	38.7	778	26.5
4	12	50.1	1,592	33.9	24.3	182.2	23.9
5	15	7.8	9.0	30.4	17.8	49	21.6
6	18	34.3	552	29.4	14.7	15.2	19.8
7	21	19.1	68.8	27.4	15.6	23	18.4
8	24	20.8	100	25.8	13.8	9.0	17.2
9	27	25.8	225	24.9	7.8	9.0	16.3
10	30	17.1	39.6	23.6	6.2	21.2	15.5
11	33	12.1	1.7	22.6	4.7	37.2	14.9
12	36	11.2	0.16	21.8	8.9	3.6	14.3
13	39	15.3	20.2	20.8	11.5	0.49	13.7
14	42	12.8	4.0	20.0	10.8	Nil	13.2
15	45	14.2	11.6	19.3	12.2	1.9	12.8
16	48	10.1	0.49	18.7	14.2	11.6	12.4
17	51	5.9	24.0	18.2	10.7	0.01	12.0
18	54	10.6	0.04	17.7			
19	57	10.7	0.01	17.2	11.1	0.09	11.7
20	60	10.9	0.01	16.8	10.9	0.01	11.4

Note.—Only slide rule accuracy has been employed and in some cases decimals have been discarded.

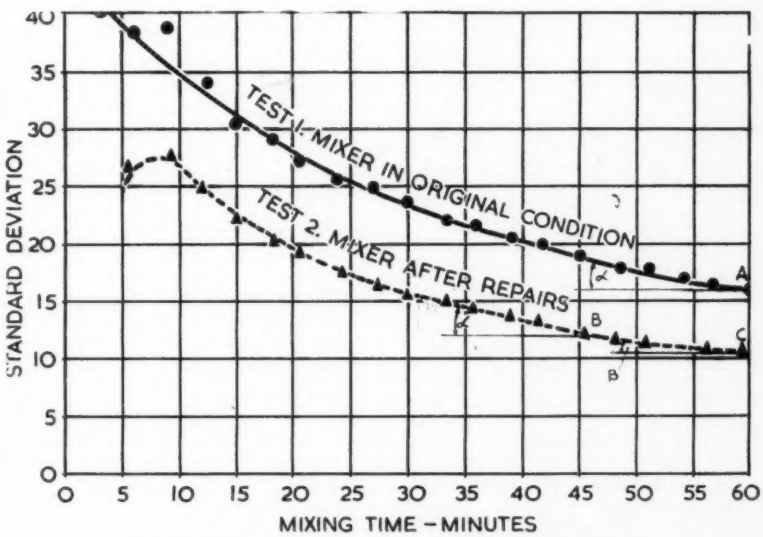


Fig. 1. Results of two tests on a sand/lime batch mixer.

was found that several of the ribbon flights were in a bad condition and the rotating element did not properly agitate the ingredients. The rotor was removed and repairs were carried out, after which the results in test run No. 2, illustrated in the lower curve, were obtained.

It will be seen that, if the factory management were satisfied before the maintenance work with the mix provided at *A* on the upper curve, 46 min. of mixing under the new conditions were sufficient to reproduce these conditions at *B* on the lower curve. Alternatively the homogeneity of mixing at *C* is seen to be better than at *A*.

Conclusions

Useful results can be obtained by using the statistical method as an approach to solids mixing problems. The method can often lead to improvements in design or operation of machines or reveal maintenance faults.

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Emulsification and Dispersion Using Ultrasonics

By J. S. Smith

(*Technical Service Manager, Ultrasonics Ltd.*)

This article outlines the progress that has been made in the application of ultrasonic equipment, using a liquid whistle containing a vibrating blade, to the production of emulsions and dispersions.

SINCE the earliest experimental work on sound energy beyond human audibility, the possibility of employing ultrasonics for emulsification and dispersion has been appreciated. Experiments by many workers[1] since the classic work by Wood and Loomis[2] in 1927 have amply proved the tremendous potentialities of cavitation forces in the field of liquid/liquid and liquid/solid processing. The main deterrent to the widespread adoption of ultrasonic technique has always been the cost factor. Electronic equipment necessary to drive piezoelectric and magneto-strictive transducers has always been expensive and, because these were the only available systems, little practical use was made of the knowledge gained.

The most important developments in liquid processing by ultrasonics have been in the use of liquid whistles based upon original work carried out in Germany.[3] In 1952, Cottell and Goodman[4] introduced in this country the first commercial equipment employing a liquid whistle. This device, the *Rapisonic* homogeniser (Fig. 1) was the first industrial unit which made liquid processing by ultrasonics possible at an economical figure. Continuous research and development, based upon six years of industrial experience by its manufacturers, has produced a range of machines capable of dealing with a wide variety of applications.

Principles

The unit includes a specially designed pump to force the liquid to be processed through the whistle or vibrating element at the correct velocity. The vibrating element (Fig. 2) consists basically of a crossover jet which creates a flat stream of liquid. Accurately positioned in this stream is a blade which is set into vibration by the liquid stream (Fig. 3). Whilst this stream velocity is maintained, the blade will vibrate at its natural frequency which is in the order of 20 kc/s. The intensity of acoustic energy so created induces cavitation forces of some 60 tons/sq.in. in the liquid.[5] The construction of the whole vibrating element is simple and robust and only the vibrating blade and jet are subject to wear.

Considerable progress has been made in overcoming vibrating blade breakage due to metal fatigue encountered in the early days on certain heavy substances. The rate of erosion wear on the front edge of the blade is relative to the abrasiveness of the processed liquid; with most food products it is very slight, but it should be checked periodically by visual inspection. Jet wear has been reduced by the use of sintered inserts where slightly abrasive substances are handled. Standard units are suitable for a fairly wide viscosity range but, for very high viscosities, special versions are available. To meet hygiene standards, all parts in contact with the liquid are of

Fig. 1. 'Rapisonic' homogeniser.

18/8/3 stainless steel (which is also highly resistant to chemical attack) on standard units. In the case of the larger, tailor-made equipment, alternative materials are often used to reduce the cost.

Dispersions

'Fillers.' One of the first large-scale adaptations of the *Rapisonic for Dispersions* was for the high-quality dispersion of fillers in the latex foam industry. Since the early experiments six years ago, it has become well established for this purpose. It is extremely important that any filling material used in foam rubber, such as china clay, whiting, mica, zinc oxide, etc., is broken down to its unit particle size; agglomerations cause serious loss of strength in the rubber. Because of the large quantities involved, a quick

and efficient method is required. In most cases, a single pass through the machine suffices, and Fig. 4 shows a typical installation. The powder is premixed into the water, using conventional stirrers, and is discharged through the *Rapisonic* machine into a storage vessel, also stirred to prevent re-agglomeration.

The standard version has a throughput of 300 gal./hr., but larger units are available up to 1,000 gal./hr. The standard machines will handle up to approximately 60% solid content and, with slight adaptations, up to 75% solids. If, on a particular formulation, more than one pass is desirable, two units can be arranged in series, or a second pass given by transfer. Maintenance of these units is easy, and chiefly involves replacing the vibrating blade at determined intervals. The blades are cheap, and can be fitted in a few minutes. The pump components subject to wear can also be replaced easily and the whole operation can be completed within 1 hr.

Pigments. Although the ball mill has, for many years, been the accepted method of obtaining dispersions of pigments in oil and water, there are many dispersions in which actual grinding is unnecessary or even undesirable. For example, titanium dioxide dispersions require only the wetting-out and breaking-up of loosely held agglomerates; this can be achieved with the ultrasonic equipment at a fraction of the capital and running costs of a ball mill. Another advantage of this method is that, where the dispersion is required for addition to other liquids, the machine can discharge directly into the final mixing vessel, thus avoiding the use of a holding tank in which re-agglomeration can occur. During the last two years experiments in the plastic, textile, ink and paint industries have shown great promise, and already there are a considerable number of units working in production.

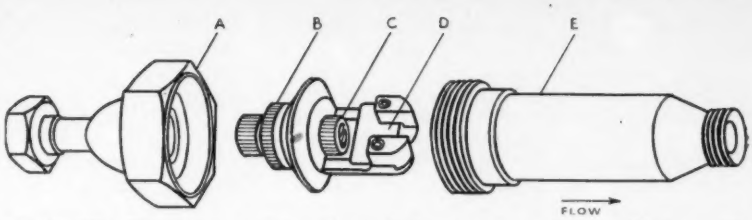

Fig. 2. Vibrating element of the ultrasonic homogeniser, showing (A) base, (B) adjustable jet body, (C) jet insert, (D) vibrating blade, (E) resonant bell.

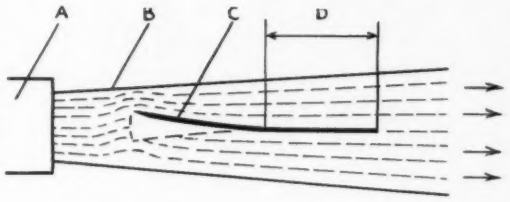

Fig. 3. Diagrammatic section showing (A) jet, (B) liquid stream, (C) vibrating deflected, showing cavity formed, (D) clamped portion of blade.

Carbon black. The standard ultrasonic homogeniser is well suited to the dispersion of carbon black in oil, water and wax because of its simplicity and ease of cleaning. With most grades of carbon black there is no difficulty in achieving particle sizes of around 1 micron, and it can handle high solid/liquid dispersions for shoe polish and carbon paper coatings without entraining air. A consistently good product can be made using unskilled labour.

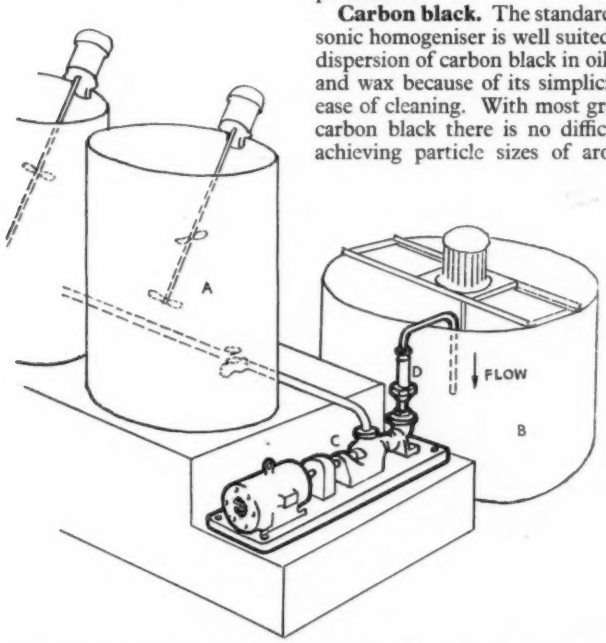

Fig. 4. Typical installation for dispersion of fillers for latex foam, showing (A) premix vessels, (B) storage vessel, (C) pump unit and (D) vibrating element.

Mixes and emulsions

Mineral oil emulsions have, in many cases, been produced by uneconomical means. It is possible to make many by stirring, but only when using an excess of emulsifying agent. It has been possible to show great savings on large quantities by using ultrasonic emulsification, which enables the emulsifying agent to be reduced to an absolute minimum. Fig. 5 shows a large installation using ultrasonic homogenising equipment.

The gradual emulsification method is employed, *i.e.* the disperse phase is admitted at a controlled flow into the recirculating continuous phase. When this cycle is completed, the whole batch is given a refining pass into the storage vessel, from which the product is drained off into barrels. When very large quantities are needed, a continuous metered-phase method is used.

Starch mixes. The earliest work on ultrasonic homogenisation of starch was done in the cotton warp-sizing industry, and a special unit was developed which gives quick gelatinisation without prolonged boiling; the starch and lubricant addition (usually tallow) is reduced to a very fine particle size. A series of experiments was carried out recently to observe the effect of ultrasonic treatment of gelatinised maize starch. The results showed an immediate fall in viscosity, which recovered slowly. This phenomenon has been applied to a textile

problem where 12% maize starch was used. Even after prolonged boiling, the viscosity was too high for it to be applied. After ultrasonic homogenisation, it was quite liquid and could be pumped and evenly applied.

Oleine emulsions. Stable oleine emulsions can be obtained with ultrasonic equipment using a minimum of emulsifying agent. In one case recently, a stable emulsion was made using $\frac{3}{4}$% agent where hitherto 7$\frac{1}{2}$% agent was necessary using a high-speed stirrer.

Creams. Pharmaceutical and cosmetic creams can be produced with ultrasonic equipment, which can even be made portable to allow it to be moved about the plant. Because it is fundamentally a closed system, the product, no matter how viscous, can be made free from aeration. With creams, lower temperatures can be employed in many instances, and the old-fashioned technique of stirring until cold can be abandoned.

Food industry applications

Soups. In the preparation of mushroom, tomato and similar cream soups, ultrasonics provide an economical means of homogenisation. The hot soup is either recirculated in the kettle or given definite transfer passes between two kettles. The effect of ultrasonics upon diluted tomato purée is very interesting; instead of a gradual settlement and a clear water-layer on top, in many cases almost permanent stabilisation occurs, giving an enhanced appearance to the product. The treatment can be given in a hot or cold condition, and one pass through the homogeniser suffices.

Chocolate. Whilst very much experimental work has yet to be done before 'conching' ultrasonically is an industrial possibility, blending and texture improvement of couverture chocolate by ultrasonic means presents considerable attractions. This is particularly true where large quantities can be handled on a continuous or semi-continuous basis. For example, when two different chocolates are metered into the *Rapisonic*, a perfect blend and reduction of the emulsion particle size is obtained with a throughput of approximately 60 lb./min. The whole unit can be jacketed while retaining ease of dismantling for inspection and cleaning.

Essential oils. Ultrasonics provide a convenient method of producing a range of essential oil emulsions. The problem has always been to control the particle size within the desired limits. In some cases, particularly in those countries whose regulations prohibit the use of brominated oils, it is necessary to have a final particle size of 1 to 2 microns, otherwise the emulsion is insufficiently stable. In other cases, slightly larger particles of 2 to 4 microns are desirable to retain the clouding characteristics of the emulsion. These emulsions can often be achieved satisfactorily using high-pressure homogenisers, but the higher output rate possible using ultrasonic technique is particularly attractive in such a seasonal trade. The machine is usually mounted on a specially designed trolley so that it can be moved around the factory from vessel to vessel.

Other applications

Fat liquors, etc. The whole range of emulsions used in the leather industry can be made with the *Rapisonic*, and Fig. 6 shows an economical arrangement suitable for making batches of up to 30 to 50 gal. Whilst suction lift is undesirable in many cases, it is used here for simplicity. A pre-mix is made in one vessel, with manual stirring, and the finished emulsion is discharged into the second barrel. Since this will take only about 10 min., in many instances a short recirculation is first given to ensure thorough emulsification.

Wax emulsions. Many wax emulsions are difficult to pre-mix, because rapid stirring tends to cause frothing and therefore complicated procedures are employed. In such cases (as, for example, in an emulsion wax polish) the wax is heated in a small kettle, the aqueous phase is recirculated with the ultrasonic homogeniser, and the wax can be introduced into the homogeniser (using the secondary inlet) at a controlled speed. By this method, once the right conditions are established, stable emulsions can be produced by unskilled labour at minimum cost. Wax emulsions are notoriously difficult to make, and careful formulation is essential. Some experimental work may be necessary to determine the ideal temperatures, etc., which will best suit the formula.

Coolant emulsions. In the engineering industry, economies ensue when mineral oil coolants are efficiently emulsified. The practice of using self-emulsifying oils is wasteful if large quantities are required. A small unit using an ultrasonic homogeniser can supply the entire demands of the plant. The difference in cost between self-emulsifying oil as compared with a straight oil, and a suitable emulsifying agent, is worth consideration; the plant will show a profit over a reasonable period.

In oil-well drilling work, where a rough emulsion is used to cool the bit, very often large quantities of emulsifying agent are used. This could be

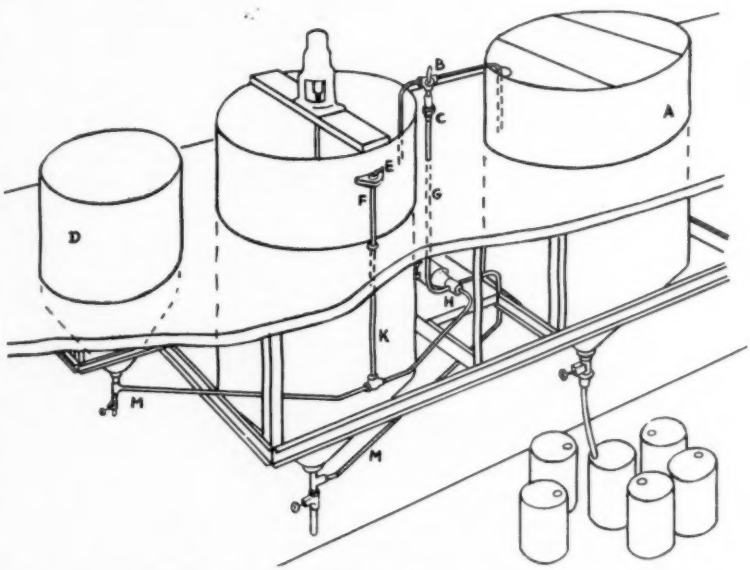

Fig. 5. Large installation for mineral oil emulsions. Components are: (A) Storage tank, (B) three-way valve, (C) vibrating element, (D) oil tank (disperse phase), (E) graduated valve control handle, (F) extended valve spindle, (G) delivery pipe, 1$\frac{1}{2}$ in. diam., (H) pump and motor unit, (K) secondary inlet valve, (M) suction pipe, 2 in. diam.

avoided by cutting the proportion down to the absolute minimum and feeding the emulsion straight from the homogeniser to the bit.

Bitumen emulsions. Steam- or oil-jacketed versions of the *Rapisonic* are available for tar and bitumen emulsion work. The system has no temperature restrictions, and there is no limitation in size or output. Excellent results have been obtained on the making up of bentonite stabilisers, which are used in this industry as well as in the paint industry. One pass of a rough slurry made with hot water suffices to form a completely gelled colloidal solution. Some of the low-melting-point bitumen emulsions can be made with standard, non-jacketed machines, providing that the pump and vibrating element are pre-heated.

Conclusion

Ultrasonic processing is now accepted by many industries as the successor to the high-pressure piston homogeniser and the colloid mill wherever emulsions or dispersions are made. But its greatest undeveloped application is that of continuous intimate mixing in a pipeline. Very high-quality mixing and blending of a number of liquids on a continuous basis is certainly a field in which little equipment is available at a reasonable cost.

For the larger ultrasonic homogenisers, multiple vibrating elements are used, and considerable development work is still required before larger liquid whistles, giving higher energy levels at higher outputs, are a commercial proposition. The speeding up of chemical reactions hold many possibilities for ultrasonic homogenisation, because intimate mixing can be done in a closed system, at elevated temperatures and on a continuous basis. Where stainless steel is unsuitable, units can be made in other metals.

In the processing of liquids by ultrasonics, the liquid whistle has proved to be the only practical method of

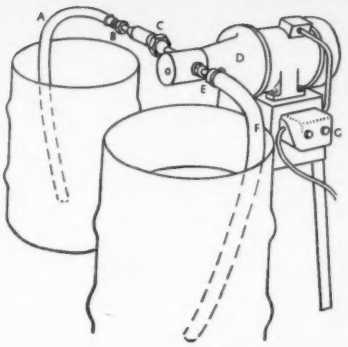

Fig. 6. Arrangement for making up to 30 to 50-gal. batches of emulsions for the leather industry: (A) delivery hose, 1-in.-diam. synthetic rubber, (B) tailpiece and nut for 1-in. hose, (C) vibrating element, (D) pump and motor unit, (E) tailpiece and nut for 1½-in. hose, (F) suction hose, 1½-in.-diam. synthetic rubber, (G) push-button starter.

generating energy. Although most of the early workers in the field used crystal or magneto-strictive equipment for their experiments, their results could not be applied on production scale until the liquid whistle was developed. Much of this work was done with frequencies in the 1-megacycle range and it has been interesting to learn how, in many cases, similar results have been obtained in the 20-kc/s. range. The whole field of ultrasonics has passed through an embarrassing period of over-popularisation, in which many rash claims were made. There is no doubt that there remain many problems which can be effectively solved by using the latent energy of cavitation which is released by ultrasonic technique.

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[3] W. Janovsky and R. Pohlmann, *Z. Angew Phys.*, 1948, **1**, 222.

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[5] Lord Rayleigh, *Phil. Mag.*, 1917, **34**, 94.

Each month CHEMICAL & PROCESS ENGINEERING *makes a special feature of some subject of technological importance. Examples in the recent past include Materials Handling, Pipework Construction and Installation, Evaporation, and Gas Cleaning, in addition to the special survey of Mixing concluded above. Next month's special feature will be on:*

Flow Indication, Recording and Control

Higher grades of benzole

Hydrorefining is the ' process of the future ' for the benzole refining industry, according to a recent report which gives the results of pilot-plant investigations at the Thorncliffe, Lancs., works of Newton Chambers & Co. Ltd. These followed laboratory-scale experiments by the Coal Tar Research Association and now a considerable amount of experience and know-how has been accumulated on the application of the hydrorefining technique to British benzoles.

In a paper presented to the Midland Section of the Coke Oven Managers Association, Mr. R. Middleton and Mr. D. Bradley, both of Newton Chambers, explained how the problems had been tackled, not only with a view to meeting the present specifications for purer benzoles but also to meet the more stringent specifications likely to concern the benzole refiner in the immediate future. Benzoles were classified into three categories: (*a*) The low-gravity benzole from which high-grade benzene could not be prepared by distillation, (*b*) the benzoles with a small quantity of paraffin in the crude state, and (*c*) the paraffin-free crude benzoles. It was shown that the production of pure products of high quality from classes (*b*) and (*c*) by distillation was not only economical but much more remunerative than by acid-washing processes.

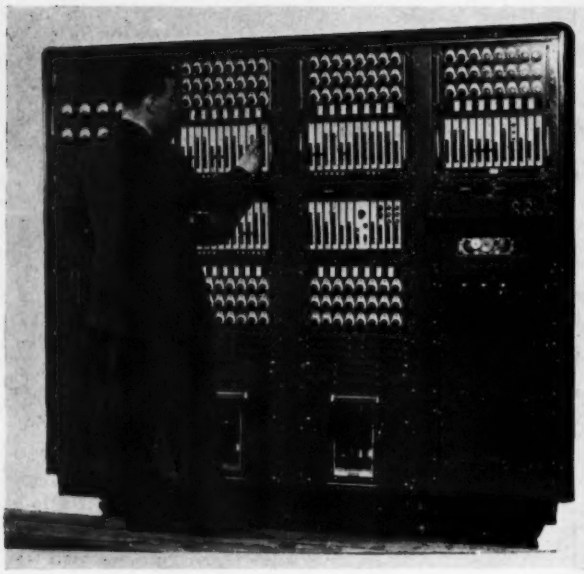
A freezing technique for the production of super-quality benzene was described. This not only decreased further the cost of pure product manufacture from classes (*b*) and (*c*) but encompassed class (*a*) benzoles from which benzene had not previously been extracted. Processes had been evolved in the treatment of hydrorefined material which gave benzene in substantially complete yields.

As a result, the authors had reached the firm conclusion that the application of these techniques to any benzole was financially and technically attractive and that the immediate installation of hydrorefining equipment to produce materials to satisfy present specifications would place refiners in an advantageous position to meet what must surely come—a market which could only be satisfied by higher grades of benzene.

A hydrorefining plant was essentially a continuous automatically controlled plant, it was stated, and such an installation could be so operated as to produce a hydrorefined material from which benzene of any grade of purity could be produced.

Chemical Process Design on an Analogue Computer

By D. S. Terrett, B.Sc.
(Fairey Aviation Co. Ltd.)



Above: **Setting up the Fairey Aviation multi-purpose analogue computer for solving the problem discussed in the article. In the picture the function units are being inserted.**

Right: **Another operation in the setting up of the computer: adjustment of the function generator breakpoint.**

THE control of chemical processes often presents problems which are difficult and unwieldy to solve by normal manual methods of computation. A characteristic problem of this type is the jacketed-pan system, described below, for which optimum control parameters were to be determined. This investigation was carried out by means of an analogue computer on which various changes were tried until a satisfactory solution was obtained.

The layout of the plant used for this investigation is shown in Fig. 1. A continuous flow of liquid passes through the pan, the contents of which are well agitated. Its temperature Θ_p is maintained constant by regulating the temperature of the water in the surrounding jacket. This water is circulated through the jacket at a constant rate by means of a pump P which is fed from the surge tank S. The water leaving the jacket passes back into the surge tank where a controlled quantity of steam is injected to heat its contents. Under steady-state conditions a fixed flow of steam is required to maintain the temperature of the pan at the desired value. Variations of input temperature and flow rate through the pan necessitate changes of steam flow into the surge tank to maintain the pan temperature constant, these are applied by the control system shown in Fig. 2.

Two systems were investigated: a single-loop system where the temperature error $(\Theta_p - \Theta_{p\text{-desired}})$ is used to control the steam valve, and a double-loop or cascaded system where temperature feedback is applied from both the pan and jacket.

Several questions are answered by the simulation:

(*a*) Is the double-loop system superior to the single-loop system?
(*b*) What are the optimum settings for the controller?
(*c*) How much and for how long will the outlet temperature depart from the desired value when a change of input temperature occurs?
(*d*) Is the system satisfactory for changes of flow rate through the pan?

Setting up the problem

Before this problem can be set up on the computer it is first necessary to derive equations or relationships for each component of the system. As the operation of this system is a very complex process with factors such as heat loss, liquid turbulence and changing heat-transfer coefficients entering into the picture, it is necessary to make a number of simplifying assumptions.

These are:

The previous two articles in this series discussed the function of the component parts of the analogue computer, and its applications in the process field. This third article shows how a chemical process and its proposed control system were set up for solution by simulation on a computer.

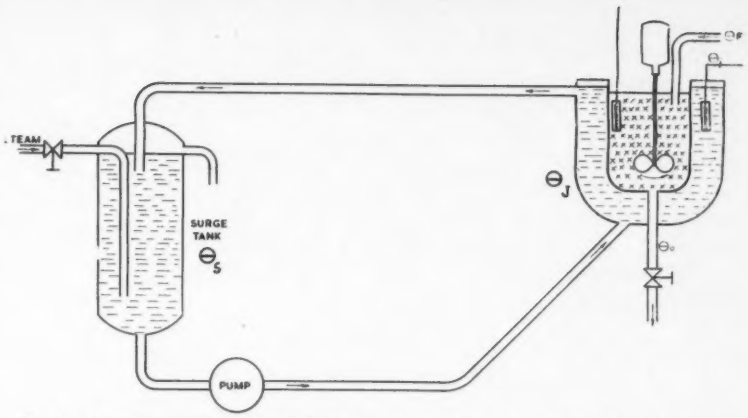


Fig. 1. Arrangement of jacketed-pan system used for computer investigation.

(i) The heat losses through the jacket wall, surge tank walls and pan cover, which are small and ill defined, can be neglected.

(ii) Perfect mixing occurs in the pan, jacket and surge tank.

(iii) The total mass of the pan wall is all at the same temperature. To be theoretically correct the pan wall should be treated as a distributed system since there is a temperature gradient across it. As mathematical treatment of distributed parameter systems involves partial differential equations, complete simulation becomes complex. The errors introduced by using 'lumped' parameters for the wall are, however, only apparent at high frequencies and at the frequencies involved in this investigation were found to be negligible.

(iv) The heat-transfer coefficient of the pan wall is constant.

Using these assumptions it is now possible to write down the following heat-balance equations governing the response of the jacketed pan and surge tank.

For the jacket:

$$(C_J + V_J \rho_w s_w)\frac{d\theta_J}{dt} = (\Theta_s - \Theta_J)\, F_1 \rho_w s_w - \frac{(\Theta_J - \Theta_w)}{R} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

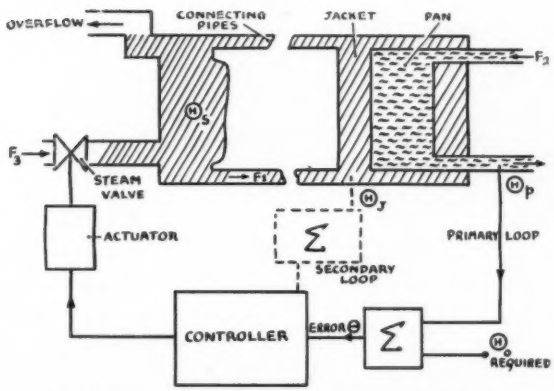


Fig. 2. Schematic diagram showing control loop.

For the pan walls:

$$C_w \frac{d\Theta_w}{dt} = \frac{(\Theta_J - \Theta_w)}{R} - \frac{(\Theta_w - \Theta_p)}{R^\star} \quad \ldots\ldots (2)$$

For the contents of the pan:

$$V_p \rho_p S_p \frac{d\Theta_p}{dt} = \frac{(\Theta_w - \Theta_p)}{R^\star} + (\Theta_1 - \Theta_p) F_2 \rho_p s_p \ldots (3)$$

For the surge tank:

$$(C_s + V_s \rho_w s_w)\frac{d\Theta_s}{dt} = (\Theta_J - \Theta_s) F_1 \rho_w s_w + F_3(H - \Theta_s)\rho_w s_w \quad \ldots\ldots\ldots\ldots (4)$$

where

C_J = heat capacity of external jacket walls
V_J = volume of water in the jacket
ρ_w = density of water
s_w = specific heat of water
F_1 = flow rate of the water circulating system
R = thermal resistance of jacket side of dividing wall
$R^\star$ = thermal resistance of pan side of dividing wall
Θ_J = temperature of jacket
Θ_s = temperature of surge tank
Θ_w = temperature of dividing wall
C_w = thermal capacity of dividing wall
V_P = volume of pan
ρ_p = density of fluid in pan
S_p = specific heat of the fluid in pan
F_2 = flow rate of pan fluid
C_s = thermal capacity of surge tank walls
V_s = volume of surge tank
F_3 = flow of steam into surge tank
H = heat content of steam at 50 p.s.i.

These four first-order differential equations show that the rate of change of temperature in any one compartment of the process is proportional to the net amount of heat entering or leaving that compartment.

Substituting proper numerical values (Table 1) in these equations we get:

$$\frac{d\Theta_J}{dt} = 6.452\ \Theta_s - 16.55\ \Theta_J + 10.01\ \Theta_w \quad \ldots\ldots (5)$$

$$\frac{d\Theta_w}{dt} = 469.5\ \Theta_J - 995.8\ \Theta_w + 526.3\ \Theta_p \quad \ldots\ldots (6)$$

$$\frac{d\Theta_p}{dt} = 14.17\ \Theta_w - 15.51\ \Theta_p + 1.33\ \Theta_i \quad \ldots\ldots (7)$$

$$\frac{d\Theta_s}{dt} = 9.524\ \Theta_J - 9.524\ \Theta_s - 0.00032\ F_3\Theta_s + 0.383\ F_s \quad \ldots\ldots\ldots\ldots (8)$$

Units of temperature are in each case given in degrees Fahrenheit per hour.

Steady-state solution

If the desired pan outlet temperature is 120°F. and the nominal input temperature at its inlet is 90°F., the steady-state temperatures of the jacket and surge tank may be calculated by solving equations (5) to (7) when

$$\frac{d\Theta_J}{dt} = \frac{d\Theta_w}{dt} = \frac{d\Theta_p}{dt} = \frac{d\Theta_s}{dt} = 0$$

These equations give $\bar{\Theta}_s = 130.9°\text{F.}$, $\bar{\Theta}_J = 126°\text{F.}$

From these results the steady flow of steam into the surge tank may be calculated.

$$F_3H - F_3\Theta_s = F_2(\Theta_p - \Theta_1)\rho_p S_p$$

which gives $\bar{F}_3 = 138.14$ lb./hr.

Dynamic solution

In studying the dynamic performance of this system on the computer it is convenient to consider only the variations about the mean or steady-state values. Hence for Θ_s, Θ_J, Θ_p and F_3 we may write

$$\Theta_s = \bar{\Theta}_s + \theta_s \qquad \Theta_p = \bar{\Theta}_p + \theta_p$$
$$\Theta_J = \bar{\Theta}_J + \theta_J \qquad F_3 = \bar{F}_3 + f_3$$

Putting these into equations (5) to (8) and eliminating the steady-state values we get:

$$\frac{d\theta_J}{dt} = 6.452\ \theta_s - 16.55\ \theta_J + 10.01\ \theta_w \quad \ldots\ldots\ldots (9)$$

$$\frac{d\theta_w}{dt} = 469.5\ \theta_J - 995.8\ \theta_w + 526.3\ \theta_p \quad \ldots\ldots\ldots (10)$$

$$\frac{d\theta_p}{dt} = 14.17\ \theta_w - 15.51\ \theta_p + 1.33\ \theta_i \quad \ldots\ldots\ldots (11)$$

$$\frac{d\theta_s}{dt} = 9.524\ \theta_J - 9.586 + 0.3411 f_3 - 0.00032 f_3\theta_s \quad \ldots (12)$$

Table 1. Numerical Values (Constants)

Quantity	*Value*	*Units*
C_J	150	B.Th.U.
C_w	100	B.Th.U.
C_s	150	B.Th.U.
V_J	450	Gal.
V_p	750	Gal.
V_s	300	Gal.
ρ_w	1	
ρ_p	0.45	
S_w	1	
S_p	1.1	
R	2.13×10^{-5}	°F.hr. B.Th.U.
R^*	1.9×10^{-5}	°F.hr. B.Th.U.

Table 2. Numerical Values (Steady State)

Quantity	*Value*	*Units*
F_1	3,000	Gal./hr.
F_2	1,000	Gal./hr.
F_3	138	Lb./hr.
θ_{IN}	90	°F.
θ_p	120	°F.
θ_w	122.8	°F.
θ_J	126.0	°F.
θ_s	131.0	°F.

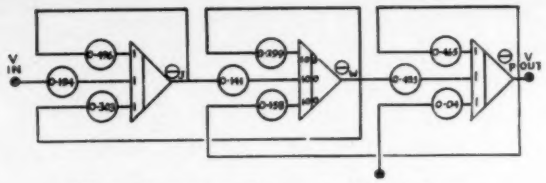


Fig. 3. Computer diagram for jacketed pan.

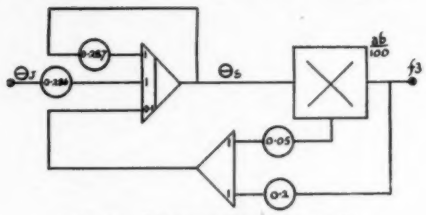


Fig. 4. Diagram for surge tank.

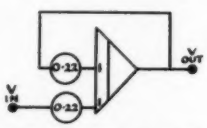


Fig. 5. Simulation of time lag in pipes.

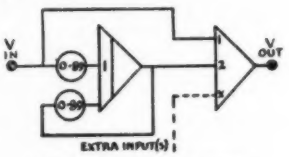


Fig. 6. Resistance bulb thermometer.

The next step in arranging these equations for solution on the computer is to choose a suitable voltage scale factor. For temperature let one volt on the machine = 3°F. For steam flow let one volt on the machine = 6 lb./hr.

Adopting the methods of scaling demonstrated in the previous article we get:

$$3\frac{d\left[\frac{\theta_J}{3}\right]}{dt} = 19.36\left[\frac{\theta_s}{3}\right] - 49.64\left[\frac{\theta_J}{3}\right] + 30.28\left[\frac{\theta_w}{3}\right] \quad \ldots\ldots\ldots\ldots (13)$$

$$3\frac{d\left[\frac{\theta_w}{3}\right]}{dt} = 1{,}408\left[\frac{\theta_J}{3}\right] - 2{,}987\left[\frac{\theta_w}{3}\right] + 1{,}579\left[\frac{\theta_p}{3}\right] \quad \ldots\ldots\ldots\ldots (14)$$

$$3\frac{d\left[\frac{\theta_p}{3}\right]}{dt} = 42.53\left[\frac{\theta_w}{3}\right] - 46.53\left[\frac{\theta_p}{3}\right] + 3.999\left[\frac{\theta_i}{3}\right] \quad \ldots\ldots\ldots\ldots (15)$$

$$3\frac{d\left[\frac{\theta_s}{3}\right]}{dt} = 28.57\left[\frac{\theta_J}{3}\right] - 28.7\left[\frac{\theta_s}{3}\right] + 2.047\left[\frac{f_3}{6}\right] - 0.57\left[\frac{F_3}{6}\right]\left\{\frac{\left[\frac{\theta_s}{3}\right]}{100}\right\} \quad \ldots\ldots\ldots\ldots (16)$$

As computer time is usually given in seconds, let us now convert the equations into seconds by substituting $3{,}600\ t = t'$ or

$$\frac{d}{dt} = 3{,}600\frac{d}{dt'}$$

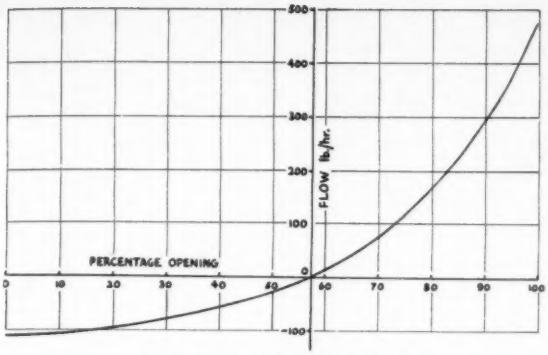


Fig. 7. Valve characteristics.

If the above equations are now set up on the computer using this substitution the solution will appear in real time. As the time constants involved are long, it is convenient for easy observation to speed up the time scale on the computer. Let us choose a time-scale change so that 108 seconds of real time t' is equivalent to one second of machine time τ.

Then $t' = 108\tau$

$$\text{and} \quad \frac{d}{dt'} = \frac{1}{108}\frac{d}{dt}$$

$$\text{Hence} \quad \frac{d}{dt} = \frac{100}{3}\frac{d}{dt}$$

and equations (13), (14), (15) and (16) become

$$\frac{d\left[\frac{\theta_J}{3}\right]}{dt} = 0.194\left[\frac{\theta_s}{3}\right] - 0.496\left[\frac{\theta_J}{3}\right] + 0.303\left[\frac{\theta_w}{3}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (17)$$

$$\frac{d\left[\frac{\theta_w}{3}\right]}{dt} = \left\{0.141\left[\frac{\theta_J}{3}\right] - 0.299\left[\frac{\theta_w}{3}\right] + 0.158\left[\frac{\theta_p}{3}\right]\right\} \times 10^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (18)$$

$$\frac{d\left[\frac{\theta_p}{3}\right]}{dt} = 0.425\left[\frac{\theta_w}{3}\right] - 0.465\left[\frac{\theta_p}{3}\right] + 0.04\left[\frac{\theta_i}{3}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

$$\frac{d\left[\frac{\theta_s}{3}\right]}{dt} = 0.286\left[\frac{\theta_J}{3}\right] - 0.287\left[\frac{\theta_s}{3}\right] + 0.020\left[\frac{f_3}{6}\right] - 0.00516\left[\frac{f_3}{6}\right]\left\{\frac{\left[\frac{\theta_s}{3}\right]}{100}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

These equations can be set up directly on the computer by integrating both sides. The numerical values of the potentiometers and gains are given by the coefficients of the variables in these equations. The computer diagrams for the jacketed pan and surge tank are shown in Figs. 3 and 4.

Since the surge tank and the jacket are connected by pipes it is necessary to simulate the time delay caused by the liquid flow travelling their length. Each of the pipes in the system are 20 ft. long and 6 in. in diameter. Since the liquid flow rate through the jacket is 3,000 gal./hr., the time lag between an element of liquid entering the pipe and leaving the pipe $t_l = 59.5$ sec. and in machine time 1.785 sec.

This time delay may be represented as an operation on the function $f(t)$:

$$f(t - t_l) = (1 - t_l p + \tfrac{1}{2}t_l^2 p^2 \mp \ldots.) = e^{-t_l p} f(t) \ldots\ldots (21)$$

where p is the Laplace operator. The time delay operator e^{-pt_l} may be replaced by the approximation

$$\frac{1 - \frac{1}{2}\,pt_l}{1 + \frac{1}{2}\,pt_l}$$

This expression neglects the higher terms in p (which, if included, require the use of a greater number of amplifiers), but is sufficiently accurate for the frequencies encountered in the solution of this problem.

Substituting the value of t_l and changing to the machine timescale, we get

$$e^{-p\tau_l} = \frac{1 - 0.89p}{1 + 0.89p} \quad \ldots\ldots\ldots\ldots\ldots (22)$$

which may be set up on the computer as shown in Fig. 5.

Simulation of control components

Temperature transmitters. The dynamic characteristics of the complete resistance bulb thermometer used for measuring the normal jacket temperatures can be approximated to by a first order lag with an 8-sec. time constant

$$\frac{T_m}{T_1} = \frac{1}{1 + 8p} \quad \ldots\ldots\ldots\ldots\ldots (23)$$

where T_m is the measured temperature and T_1 the actual temperature.

Changing the time scale for the purposes of computation we get:

$$\frac{T_m}{T_1} = \frac{1}{1 + 0.22p} \quad \ldots\ldots\ldots\ldots\ldots (24)$$

The computer circuit required to simulate this transfer is shown in Fig. 6.

Control valve. The temperature of the process Θ_p is controlled by altering the flow of steam F_3 into the surge tank according to the output of a controller. The control valve used has an equal percentage characteristic for which the equation is

$$Q = 20\, e^{0.0341\, y_o} \quad \ldots\ldots\ldots\ldots\ldots (25)$$

where Q = flow at constant pressure drop and y_o = valve opening.

This characteristic is shown in Fig. 7 and may be simulated in the analogue computer by means of a diode function generator. This apparatus approximates to the desired curve by a number of straight-line segments. Since we are only interested in the effect of the disturbances about the steady state, the zero of the function generator was set at the point 0 in Fig. 7 where $F_3 =$ 138 lb./hr., the desired steady-state value.

The actuator moving the control valve stem is approximated to on the computer by the first-order time lag (in seconds)

$$\frac{y_o}{y_1} = \frac{1}{1 + 20p} \quad \ldots\ldots\ldots\ldots\ldots (26)$$

The complete computer circuit for simulating the actuator and valve characteristics is shown in Fig. 8.

Controller. The primary loop controller used to control the process temperature was a standard, three-term device providing proportional, integral and derivative control.

In equation form the output can be written in Laplace notation as

$$y_1 = \left\{ K + \frac{1}{pT_i} + \frac{pT_D}{1 + 0.1\,pT_D} \right\} \theta_p$$

where TD is the integral time constant and the derivative time constant K is the value of proportional gain.

The derivative term only provides accurate derivative control at low frequencies where $0.1\,pT_D << 1$; at high frequencies this term provides gain and little phase advance.

The computer set up for solving this equation is shown in Fig. 9, the proportional, integral and direct components being controlled by potentiometers K_1, K_2 and K_3, respectively.

For cascade control, signals from the jacket thermometer are fed into units giving proportional and derivative control.

Computer operation

The next step in the procedure consists of combining all the separate computer diagrams into one layout for the plant and control system by connecting all the related variables. From this diagram the problem patch panel is prepared by making the patchcord connections between amplifier inputs and outputs, potentiometers, function generators and multipliers. The patch panel is then inserted and the coefficient potentiometers set up to give the desired value of attenuation using a digital voltmeter. (This procedure ensures the potentiometers are set in the loaded condition.)

The next operation is to check sections of the simulated plant in turn. For example, it is possible to isolate the process and to introduce a voltage corresponding to a change in steam flow rate and measure the change of process outlet temperature. Similarly, it is possible to check the simulation of the controller, actuator and valve, both statically and dynamically.

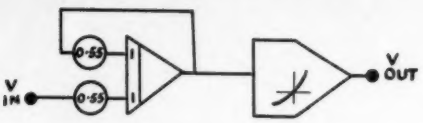


Fig. 8. Actuator and valve.

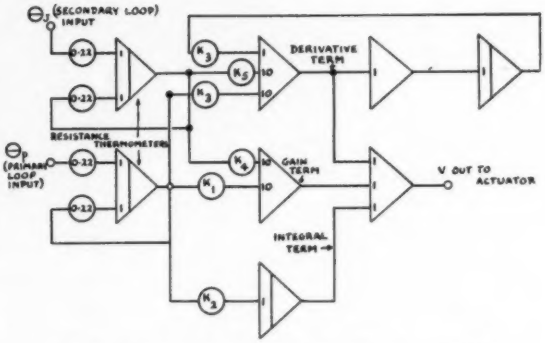


Fig. 9. Computer diagram of control equation.

Having established that the component parts of the computer are working in the desired fashion it is then possible to switch the complete system on and computation can begin. As was the case in testing components of the system, it is again advisable to make a check solution on the complete system by establishing that the simulation agrees closely with calculations for a specific case.

Once these checks have been carried out, system parameters may be changed and their effect on performance noted.

The results obtained in these investigations will be discussed in the next article in this series. The illustrations on page 58 show part of the procedure in setting up the Fairey multi-purpose analogue computer to solve this problem.

(There will be a further article in this series).

Technology Notebook

New centre for scientific and technical literature

The Department of Scientific and Industrial Research will take over part of the former Royal Ordnance Factory at Thorp Arch, near Boston Spa, Yorks., for the use of the new National Lending Library for Science and Technology. Present proposals indicate that the library will begin operating at Thorp Arch in 1961 and become fully operational during the following year. It will cover all subjects in science and technology, except for some fields of medicine, and will make its unique collection available to research, industrial, educational and other organisations by loans and photographic reproduction.

One important activity will be the expansion of work on the translation of Russian scientific literature, now organised by the Lending Library Unit in collaboration with the National Science Foundation in the United States.

Rubber lining of chemical plant

The plant lining group of the Federation of British Rubber and Allied Manufacturers has set up a technical panel to consider the possibility of drawing up a code of practice for rubber and ebonite linings, which customers can specify at the time of ordering and thereafter rely on as a guarantee of quality in any work undertaken by members of the group.

The panel will welcome suggestions from designers and fabricators of chemical plant on points which a code of practice might usefully cover. Suggestions should be sent to The Director, Federation of British Rubber and Allied Manufacturers, 43 Bedford Square, London, W.C.1.

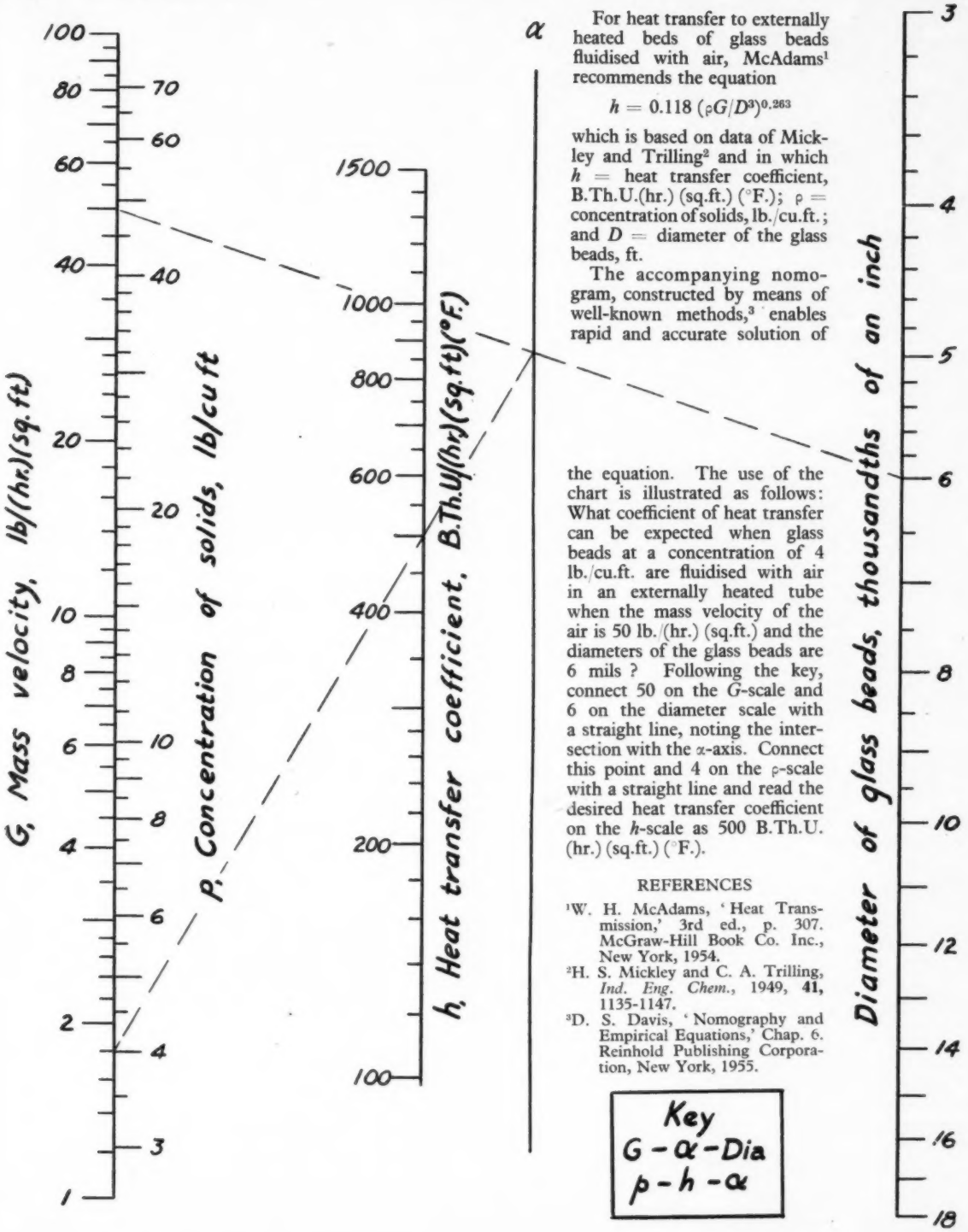
Chemical research for railways

The end of 1959 should see the completion of new chemical laboratories for British Railways Research Department, at Muswell Hill, London, which will enable certain chemical work now being conducted at various laboratories elsewhere to be concentrated and co-ordinated at one centre. The laboratory accommodation will include an Area Chemical Laboratory which will provide a general chemical service throughout East Anglia and within a radius of some 50 miles around London.

There will also be facilities for research on building materials, chemistry and corrosion.

NOMOGRAM
By D. S. Davis

Heat Transfer to Externally Heated Beds of Glass Beads Fluidised with Air


G, Mass velocity, lb/(hr.)(sq. ft.)
ρ, Concentration of solids, lb/cu ft
h, Heat transfer coefficient, B.Th.U/(hr.)(sq.ft)(°F.)
α
Diameter of glass beads, thousandths of an inch
Key
G - α - Dia
ρ - h - α

For heat transfer to externally heated beds of glass beads fluidised with air, McAdams[1] recommends the equation

$$h = 0.118\,(\rho G/D^3)^{0.263}$$

which is based on data of Mickley and Trilling[2] and in which h = heat transfer coefficient, B.Th.U.(hr.) (sq.ft.) (°F.); ρ = concentration of solids, lb./cu.ft.; and D = diameter of the glass beads, ft.

The accompanying nomogram, constructed by means of well-known methods,[3] enables rapid and accurate solution of the equation. The use of the chart is illustrated as follows: What coefficient of heat transfer can be expected when glass beads at a concentration of 4 lb./cu.ft. are fluidised with air in an externally heated tube when the mass velocity of the air is 50 lb./(hr.) (sq.ft.) and the diameters of the glass beads are 6 mils ? Following the key, connect 50 on the G-scale and 6 on the diameter scale with a straight line, noting the intersection with the α-axis. Connect this point and 4 on the ρ-scale with a straight line and read the desired heat transfer coefficient on the h-scale as 500 B.Th.U. (hr.) (sq.ft.) (°F.).

REFERENCES

[1] W. H. McAdams, 'Heat Transmission,' 3rd ed., p. 307. McGraw-Hill Book Co. Inc., New York, 1954.

[2] H. S. Mickley and C. A. Trilling, *Ind. Eng. Chem.*, 1949, **41**, 1135-1147.

[3] D. S. Davis, 'Nomography and Empirical Equations,' Chap. 6. Reinhold Publishing Corporation, New York, 1955.

INDUSTRY REPORTS...

I.C.I. in Australia

Roughly a third of all the manufacturing projects begun in Australia since the war have been undertaken by companies partly or wholly owned abroad. At this stage it is not within the power of Australian business to produce unaided the very large sums needed for development. In the last ten years roughly one-fifth of the total Australian gross private investment on capital equipment has come from overseas, 63% of it, nearly £A450 million, from the U.K.

These comments were made by Sir Alexander Fleck, K.B.E., F.R.S., chairman of I.C.I., at the official opening of the new £A3-million headquarters of Imperial Chemical Industries of Australia and New Zealand Ltd. at Melbourne. In the 30 years since the establishment of this company its capital and reserves have increased from about £A2 million to £A26 million, while sales have increased from less than £A1 million to over £A45 million. And, Sir Alexander pointed out, whereas 30 years ago about three-quarters of the annual turnover represented the marketing of imports from Britain, today nearly three-quarters of the total business comes from selling the products of I.C.I.A.N.Z.'s own plants producing heavy chemicals, alkali, explosives, plastics, etc.

Sir Alexander referred to Australia's increasing manufacturing activities and pointed out that the country, concomitant with its increased industrialisation, has become I.C.I.'s largest individual customer among an I.C.I. annual export total of nearly £A100 million.

Distillation

New distillation plant and ancillary equipment of the Midland Tar Distillers Ltd. are complete and are being commissioned at the Nechells works, though there is still a good deal to be done in the redevelopment of the remainder of the works, states the company's annual report. Costs and yields at the Four Ashes refinery, which produces phenol, refined cresylic acids, pyridine, naphthalene and other by-products, give cause for considerable satisfaction. The production of secondary derivatives with known and potential uses is being further explored.

The raw materials for the Four Ashes works are the products of the primary distillation which takes place, very largely, at Oldbury.

Electrical gear for industry

The introduction of a new range of medium-voltage, air-break, cubicle-type switchgear, known as class OB23M, was one of the highlights of the English Electric Co.'s activities in 1958, states the company's annual review. The first board, consisting of 10 panels, was delivered to the Wilton works of I.C.I. in July and was followed by a further, similar board.

The review also records one of the largest rectifier orders ever placed with a United Kingdom manufacturer, with a total rating of 171,630 kw. English Electric steel tank rectifiers will be used, at 765 v., for the electrolytic production of hydrogen and heavy water in the fertiliser factory of Nangal Fertilisers & Chemicals (Private) Ltd., of New Delhi.

A variable-speed drive was successfully commissioned at the new beet diffusion plant of the Irish Sugar Co.'s Carlow factory. It followed a similar order for their Mallow factory.

Nickel industry

Nickel production capacity in the free world in 1958 is estimated to be about 525 million lb., said Dr. J. F. Thomson, chairman of the International Nickel Co. of Canada Ltd., in his review for 1958. Total consumption is expected to be between 325 million and 335 million lb., compared with 415 million lb. for the previous year.

Stainless steels accounted for 28% of consumption; engineering alloy steels, 16%; nickel speciality alloys, 16%; foundry products, 15%; electroplating, 14%; copper and aluminium-base alloys, 6%; and 'miscellaneous,' 5%.

New applications included heat-treated high-strength structural plates and shapes containing about 3% nickel for bridges, pressure vessels and hulls for naval vessels. Heat exchanger applications continued to be the major market for cupro-nickel alloys containing from 10 to 30% nickel. A good potential market, said Dr. Thompson, is the nickel-cadmium storage battery, for which Inco have developed a special nickel-carbonyl powder.

Synthetic rubber

New installations for the production of synthetic rubber, which went into service in April 1958, are mentioned in the annual report of E.N.I. (Italian State Corporation for Oil and Natural Gas). Units for the production of styrene were at the time still in the course of erection and preparations were being made to build a second plant for the production of butadiene. This plant is due to begin working during 1959 using butane produced by the group's refineries. When all the installations have been completed, the plant will have an annual output capacity of 60,000 tons of synthetic rubber and 750,000 tons of fertilisers.

During 1957 the refineries connected with the group processed 5,475,000 tons of raw materials. The big A.N.I.C. petrochemical plant at Ravenna was inaugurated in April. In the field of nitrogenous products, production of ammonia, nitric acid, ammonium nitrate and ammonium sulphate began between the end of 1957 and April 1958.

Coastal storage tanks for crude oil from the Gela field have been complemented by plant for atmospheric and vacuum distillation, with an initial capacity of approximately 100,000 tons p.a.

Aluminium's future

Consumption of aluminium in the future is expected to increase by over 5% p.a., said Lord Portal of Hungerford, chairman of the British Aluminium Co. Ltd., in a letter to shareholders. Demand over the last 50 years had grown at a rate equivalent to some 11% p.a. Consumption, therefore, should be doubled in about 14 years.

To Authors of Technical Articles and Books

The Editor welcomes practical articles and notes on chemical engineering and related subjects with a view to publication. A preliminary synopsis outlining the subject should be sent to The Editor, CHEMICAL & PROCESS ENGINEERING, Leonard Hill House, Eden Street, London, N.W.1.

In addition, the Publishers and Editors of the Leonard Hill Technical Group are always ready to consider technical and scientific manuscripts with a view to publication. Correspondence should be addressed in the first instance to the Book Production Manager, at the above address.

WHAT'S NEWS about

★ Plant
★ Equipment
★ Materials
★ Processes

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Keeps a tight control on pressure

A new air-operated pressure controller features a pilot relay of the non-bleed, slack-diaphragm type with a large air capacity and makes possible increased valve stroking speed. The proportional mechanism incorporates a bellows-operated negative feedback system giving maximum sensitivity and reproducibility. With this proportional mechanism the proportional band can be adjusted as low as 1% of the instrument range, enabling the controlled pressure to be kept within close limits even when wide load changes are experienced.

The pressure element, available in bronze or stainless steel, can be either of the Bourdon tube or bellows type, covering all ranges from full vacuum up to 10,000 p.s.i. Crosby Valve & Engineering Co. Ltd. are the makers.

CPE 1142

More resins for chromatography

Special grades of ion-exchange materials for chromatography being offered by the Permutit Co. Ltd. now include: *Zeo-Karb* 226, a carboxylic resin of cross-linked polymethacrylic acid; *De-Acidite* G, a weak-base polystyrene tertiary amine resin; and *De-Acidite* H, mixed-base polystyrene tertiary and quarternary resin.

Altogether 68 special grades of ion-exchange materials are available in different mesh sizes and cross linkings, as well as the standard grades.

CPE 1143

Snug cradle for carboys

Good balance and easy pouring are claimed as features of a carboy tilting stand in which the sliding clamp does not touch the iron ' skip ' but clamps down gently but firmly on the top of the glass ' bottle.' Another feature of this unit is that there is no metal ring surrounding the neck of the bottle and it is claimed that uninterrupted access to neck of the bottle when pouring reduces the danger of spilling.

The tilting cradle is designed with a dropped base so that the bottom of the carboy lies snugly within a circular retaining ring. The makers, Powell & Co., say that, when the carboy has been placed in the dropped base of the cradle and the sliding clamp has been lowered into position, it is virtually impossible for the bottle or carboy to fall from the stand, however far over they are tilted. **CPE 1144**

IT SIEVES IN SILENCE

This Invicta *high-speed sieving and straining machine measures* 3 *ft. across the sieve and runs at* 3,000 *r.p.m., powders passing the screen at rates approaching* 10 *tons/hr. and liquids at up to* 12,000 *gal./hr. Parts are interchangeable, cleaning and maintenance easy and operation silent, say the manufacturers, Russell Constructions Ltd.*

CPE 1141

DRIED IN A FLASH

The principle of evaporation of moisture from a filter cake, solid or powder in granular form, whilst the material is being carried in a hot air current through a duct, is used in the French *Ventil* flash drier, now manufactured in the U.K. by L. A. Mitchell Ltd. High thermal efficiencies are obtained by recycling controlled quantities of hot air and materials.

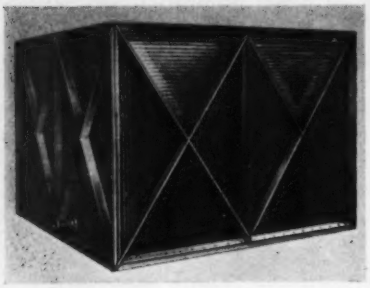
Moist material is fed from a hopper through a rotary valve into the hot air stream. A part of the moist air is exhausted from the drier through a filter by means of an auxiliary fan of low output, and the remainder is recycled. The hot air or gas for drying is introduced through a pipe after passage through the heat exchanger which is heated by steam, gas, oil or electricity.

Shortly after being introduced into the system, the moist material is mixed in the venturi with part of the dried material coming down from the cyclone separator. After passing along ducting in which drying of the material takes place, the air stream carrying the material enters the cyclone separator. The air from the top of the cyclone separator passes along the duct to the inlet side of the fan and is recirculated. The dried material is divided into two parts by the separator, the dried product being discharged through the rotary valve and the remainder passing back to the pneumatic conveyor.

This compact drier can be operated at a low temperature, thus avoiding damage to heat-sensitive materials. It is available in a range of materials of construction. **CPE 1145**

C.P.E.'S MONTHLY REPORT AND READER SERVICE

TAKES SOME TANNING



The 15,000-*gal. storage tank shown here is made from chemically-bound chopped strand glass* Duramat. *Designed and fabricated by Turner Machinery Ltd. to contain chrome tanning liquor (chromic acid), it is thought to be the largest yet produced for the tanning industry.* **CPE 1146**

Turnabout timer

Clockwise or anti-clockwise drive is possible with a new, synchronous, multi-circuit timer, this being achieved by fitting two *Rodene* self-clutching motors. When one is energised it automatically clutches on to the camshaft and drives it in one direction unimpeded by the other motor which remains un-clutched. Similarly energising the second motor drives the camshaft in the reverse direction.

The unit can have up to 24 fully adjustable twin cams, and was first produced to raise and lower the output of a set of pumps. It is also made with the two motors at one end (one being shaded to give reverse rotation), and with a variable resistor fitted to the free end of the camshaft which can be connected to re-balance a bridge when the correct number of heaters, pumps or the like have been switched on to give the rate of correction called for by the condition that unbalanced the bridge.

The cover is normally of metal but can be of non-inflammable transparent plastic. A dial showing the position of the camshaft can be fitted. Distributors are D. Robinson & Co.

CPE 1147

Versatile viscometer

Simple to operate and quickly cleaned and filled, a rotational cone-and-plate viscometer is available in standard models for up to 30° and up to 100°C., while a special high-temperature version can be used at up to 200°C.

Design features pointed out by the makers, Ferranti Ltd., are: constant rate of shear, variable from 2 to 20,000 sec.$^{-1}$ (approx.); cone speeds variable from 10 to 1,000 or 1 to 100 r.p.m.; or from 0.1 to 10 r.p.m. if required; direct reading of speed; and full torque available at all speeds.

CPE 1148

Muffle furnaces

Electric muffle furnaces for laboratory or workshop use are being produced by A.E.W. Ltd. with a heat-sealed, drop-down door (which forms a loading platform when open) while the chamber has high-grade insulation on all sides. Some models have built-in control panels with pilot lights, temperature regulator and 6 ft. of three-core cable ready for connection to mains.

Two smaller models reach their maximum working temperature of 1,000°C. in 1 hr. from cold. The larger models reach 1,000 or 1,250°C. in 2 hr. **CPE 1149**

SHEET FOR HEAT

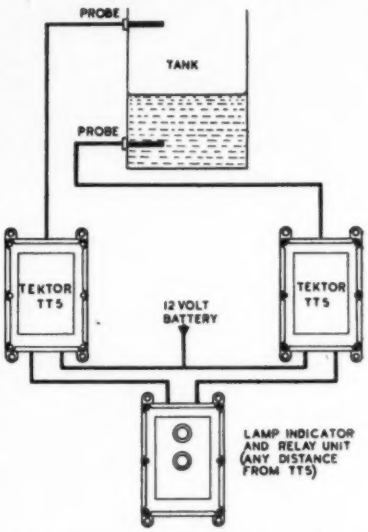
Particularly suitable for heat-transfer equipment, *Noralduct* solid aluminium sheet has integral passages which can follow almost any complex continuous pattern. Sheets can be formed after manufacture, as are those used in refrigerator evaporator components. Headers, bottles, accumulators, receivers, desiccant tubes, etc., may be incorporated in the design, and multiple separate circuits may be formed in a single sheet.

The sheeting is made (by Northern Aluminium Co. Ltd.) by superimposing a sheet of *Noral* alloy on another sheet, on which a foreshortened impression of the required tubing pattern has been printed, by a silk-screen process, in a special ' stop-weld ' ink, and then passing these sheets through a rolling mill. The high pressure that is exerted causes the aluminium to unite in all areas except those that have been inked. The rolling of what is now one sheet of metal is continued until the required final gauge and size have been obtained. The sheet is then held between rigid plain platens and the printed areas are hydraulically inflated, becoming ducts and chambers in solid sheet. **CPE 1150**

Level control—here's one for the road

High stability against supply variations of ±15% and temperature variations up to 50°C. are claimed for a new capacity level control. It can be operated from any normal 12-v. battery or accumulator and so is suitable for mobile applications such as road tankers. An indicator lamp is built in for setting up and a set/run switch is incorporated. Capacity differential is independent of electrode capacity. Provision can be made for operation from a 230-v. a.c. supply, through a mains converter, if desired.

The new instrument, the transistorised *Tektor* TT5, has no moving parts inside the container and it can be used on all liquids or free-flowing solids regardless of conductivity, insulating value, density, corrosive properties or a number of process conditions. The makers, Fielden Electronics Ltd., say it can be handled safely by unskilled personnel.



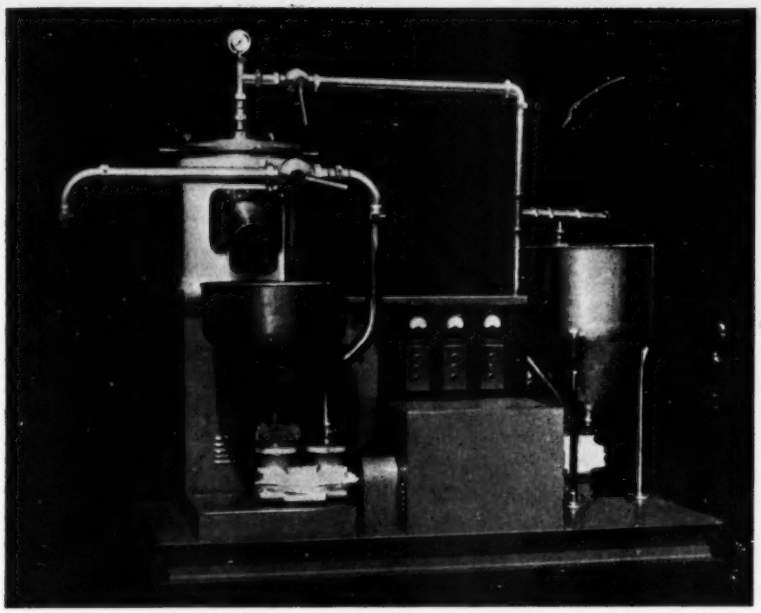
Typical level control circuit using a 'Tektor TT5'.

CPE 1151

Mercury collector

An addition to the *Polysyn* range of plastic laboratory ware is a mercury collector consisting of a hexagonal polythene container with a screwed top, a polythene tray and a threaded polythene lid with an inserted plastic foam pad.

To collect mercury accidentally spilled, the lid and foam pad are



Grease milling and deaerating unit.

removed from the container and pressed firmly against the surface on which the mercury has been spilled in such a way that all or some of the mercury globules are properly covered. The pressure applied will open up the cells in the foam pad so that the individual globules can enter. They will close up once pressure is released and the lid can then be screwed back into the container. The pressure created by closing the container re-opens the cells in the foam pad and releases the mercury. A spare pad is contained in the top of the lid. Makers are Goodburn Engineering Co. Ltd.

CPE 1152

Grease goes through the mill

Here is a new ' package ' unit that is claimed to soften grease faster than ever before—like greased lightning, you might almost say—and more economically. With motors, ammeters, switchgear and built-in fuse boxes all in one self-contained unit, it gives an output of up to 5,000 gal./hr.

According to the makers, Premier Colloid Mills Ltd., both sodium and lithium greases can be successfully processed as well as bentone greases, and either continuous or batch production can be used.

The raw grease in its resilient state is pumped from the hopper into the colloid mill where it is rapidly softened. A frothy mixture, caused by an unavoidable mixing with the air, is pumped into a deaerating plant, consisting basically of an enclosed cylinder. Passed diametrically through this cylinder is an interchangeable metal plate with a pattern of fine holes. On the underside of the plate is a high vacuum produced by a pump, which draws the frothy grease through the holes and causes the air bubbles to burst.

CPE 1153

Chemical goggles

Workers can look liquid chemicals and harmful particles straight in the eye with new, transparent goggles of which the lens is made of *Cobex* rigid PVC while the surround is made from flexible PVC. A special system of ventilation is incorporated.

The goggles can be worn over correction spectacles and two independent flaps at the bridge completely close the gap at the sides of the nose. These flaps can be trimmed to the required size and both lenses and headbands are replaceable. Makers: Fleming Safety Equipment.

CPE 1155

Semi-balanced valves

Heavy-duty, solenoid-operated globe valves of the semi-balanced type are available from Jones, Tate & Co. Ltd. with bores of from ½ to 4 in. and suitable for pressures ranging from vacuum to 200 p.s.i.g. Special valves are also available for working pressures up to 2,000 p.s.i. or for elevated temperatures.

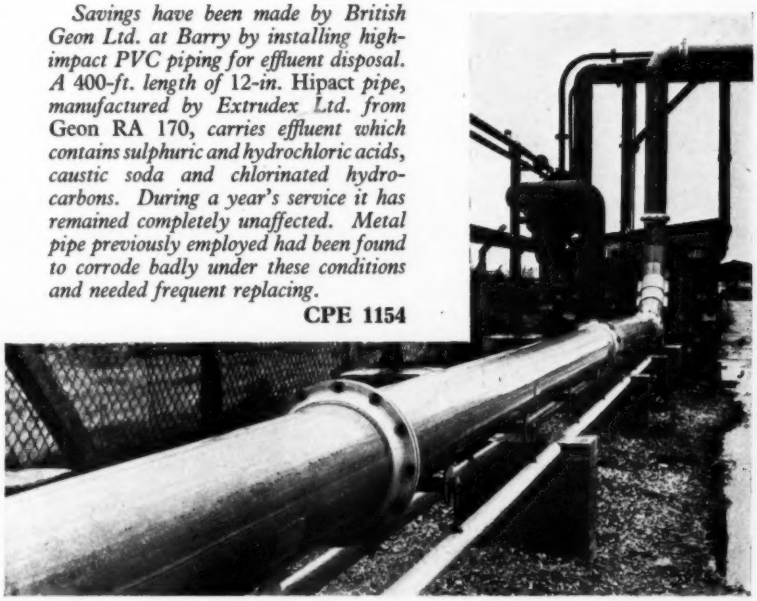
Uses of these valves include the control of hot or cold water, steam, most gases including compressed air and CO_2, liquids and refrigerants. They also have uses in temperature control, the control of oil and gaseous fuels to boilers and heating plants, and in safety cut-out service.

A design comprising two semi-

PLASTIC PIPE FOILS CORROSIVES

Savings have been made by British Geon Ltd. at Barry by installing high-impact PVC piping for effluent disposal. A 400-ft. length of 12-*in.* Hipact *pipe, manufactured by Extrudex Ltd. from* Geon RA 170, *carries effluent which contains sulphuric and hydrochloric acids, caustic soda and chlorinated hydrocarbons. During a year's service it has remained completely unaffected. Metal pipe previously employed had been found to corrode badly under these conditions and needed frequent replacing.*

CPE 1154



balanced valves, mechanically coupled, is available as a two-way, three-ported unit for diverting or mixing service.

CPE 1156

Gas regulators

Four low-price, single-stage regulators for carbon dioxide, acetylene, oxygen and propane have been produced by British Industrial Gases Ltd. They are fitted with contents gauge only, outlet pressures being adjusted by means of a screwed sleeve running over a calibration plate affixed to the body of the regulator. The oxygen regulator is calibrated in four steps, 0, 40, 80 and 120 p.s.i., and the acetylene readings are 0, 5, 10 and 15 p.s.i.

The standard bullnose-type entry is screwed into the regulator with outlet connections being $\frac{3}{8}$ in. B.S.P. Discharge to atmosphere is *via* 30 by $\frac{5}{16}$ in. hose. The makers say these regulators should be suitable for use with all standard equipment.

CPE 1157

Fork trucks keep chemical plants going

When a failure occurs or servicing becomes due in a big chemical undertaking, stand-by components have to be got at quickly. One well-known concern with plants all over Britain has solved the problem of handling spares at a central depot by the use of ' reach ' trucks with an exceptionally short wheelbase, which readily select and carry palletised items of chemical plant stored in an extensive system of shelving. Incoming goods are handled from an adjacent railway siding by ' reach ' truck and outgoing spares are loaded on to lorries. In one instance, a lorry called for an urgently needed pump and was able to leave, with the pump on board, a few minutes after its arrival.

Compactness and stability are features of the trucks, made by Lansing-Bagnall Ltd. The rear driving wheel, with the electric driving motor mounted directly above it, can be turned through an angle of 180°, so that the truck can turn in its own length. Compactness is further enhanced by the way in which the power unit, batteries and driver are contained within a shallow compartment at the rear.

In descending ramps the trucks are assisted by a unique system of regenerative braking in which the driving motor is temporarily used as a generator. Apart from providing smooth and controlled deceleration, this feature feeds current back into the batteries every time the truck slows down, and so helps to provide a full day's work on about 10 kwh. of electricity from the batteries.

CPE 1158

Handling chemical plant spares with a ' reach ' truck.

Drum shifter

Workers who like to strain their muscles by heaving drums, barrels and casks around will be disappointed if their employers bring in the latest thing in hand trucks, which enables loads of up to 6 cwt. to be moved with ease and safety. A leading edge on the front of the cradle is tapered to allow easy entry under the object to be lifted, while a grappling hook on the handle shaft can be adjusted to secure the load. The truck's wheels are made from solid, acid-resisting rubber with hardened ground bushes. No maintenance is required other than greasing of the wheel spindles.

Handy truck for containers.

The truck, manufactured and distributed by Cranmer Engineering Ltd., has an overall length of 4 ft. 6 in., while the overall height is 2 ft. 3 in. The cradle dimension is 24 by 18 by 4 in. deep and the total weight is 44 lb.

CPE 1159

AUTOMATIC TITRATOR

An automatic titrator by W. G. Pye is seen here in use with a direct-reading pH meter/millivoltmeter. The pH measuring electrode system feeds the pH meter (*right*). This in turn drives the titrator (*left*), previously set up to shut off the flow of reagent from the burette.

CPE 1160

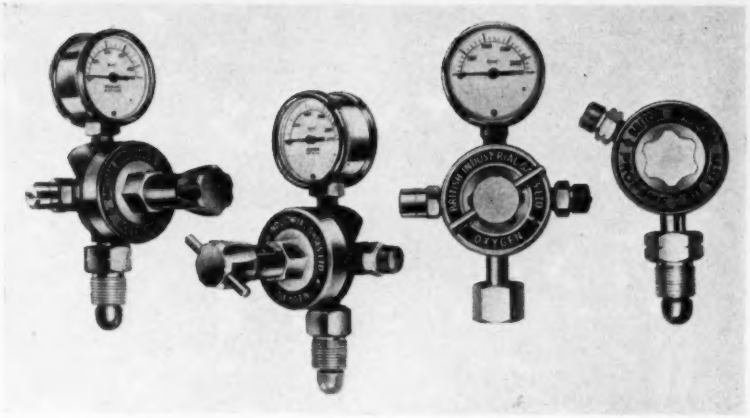
Close-control oven

A new oven introduced by the Stabilag Co. Ltd. includes a high-grade refractory brick lining and the vertically sliding door is faced with *Marinite* and is fitted with counter-balances. Behind the brickwork is a secondary thermal insulation consisting of 3-in.-thick slabs of *Caposil*. This allows a maximum temperature of 1,000°C. to be achieved on a loading of 12 kw. The makers say the loading and the maximum temperature can be increased if required.

The whole unit stands on a 20-in.-high sheet-steel base of folded and welded construction. The central portion includes a folded-back control panel which gives immediate and uninterrupted viewing of the controls from a normal standing position. On the sides are situated two terminal covers for the withdrawal of all the heating spirals which are resistance wires fitting into grooves in the base of the refractory brick lining.

The sheet metal which forms the base covers the whole of the oven apart from the door, providing an air space around the oven proper as an added measure of insulation and at the same time keeping the outer surface free from heat. Air-space insulation is also used in the observation window of the door, which consists of two layers of quartz. The oven's internal dimensions are: height 18 in., depth 12 in., width 36 in., volume 4½ cu ft.

CPE 1161



Range of single-stage regulators for gases (see opposite page).

Feeds all the time

Constant and uniform-flow feeding of any wet or dry substances, other than those which are viscous or semi-viscous, is given by the *Mikro-Feeder*, manufactured by Pulverizing Machinery Ltd. With a capacity of 2 cu. ft., it can be used as a feed unit for a ball mill, pulveriser, drier or mixer, for feeding chemicals into ore-flotation tanks and for any purpose in which a continuous feed would normally be required.

The feeder consists of a vertical, rotating shaft on which is mounted a circular feed plate and a 15-in.-diam. steel hopper, 21 in. high. Both plate and hopper rotate as one complete assembly.

The rotating shaft, feed plate and hopper are mounted on a steel housing over the drive motor and reducer gear. Secured to this housing is a shearing

PUSH-BUTTON FILTRATION

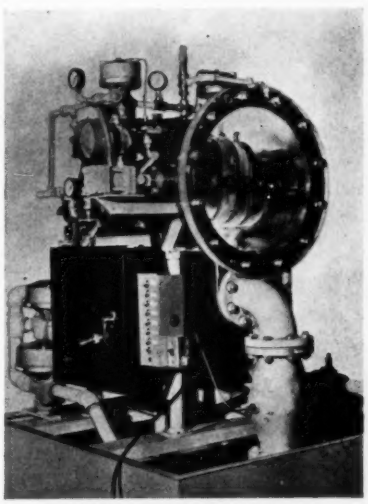
You just press a button and the filter runs itself from start to finish; it is as simple as that with a new machine we learn about from L. A. Mitchell Ltd., whose principals, Sparkler Manufacturing Co. Ltd., U.S.A., developed the idea.

At the beginning of the cycle of the Sparkler model RSC-20 filter, all valves are closed and on pressing the start button the Taylor *Flex-O-Timer* guides the filter through the proper operational procedure. First the pump starts and the suction line to the precoat tank, the filter inlet and the air vent open, permitting the filter tank to fill with precoat slurry.

As soon as the filter tank is full, the air vent closes and the filter outlet opens to discharge into the precoat tank. After a few minutes of recirculating, the precoat is deposited and the filtrate discharges to the clean filtrate tank.

The unit continues to operate until the filtering cycle is complete, when the pump stops, the outlet closes and the air-operated vibrator starts. As soon as the filter plates are clean, the screw conveyor starts, the screw conveyor discharge port opens and air enters the filter tank to discharge the spent filter cake. When the contents have been discharged, all valves close in preparation for a new cycle.

CPE 1162



Fully automatic filter.

CHLORINATOR

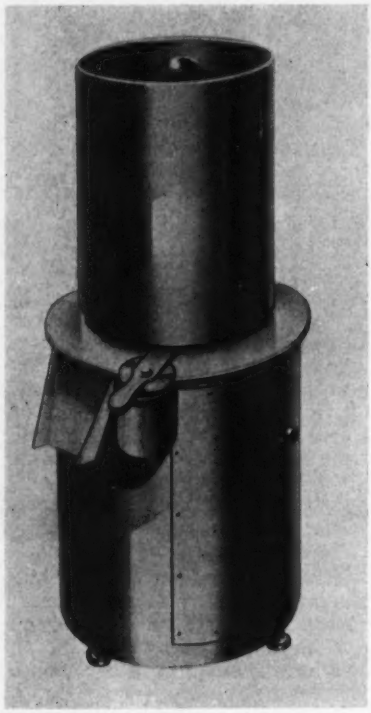
Extensive use has been made of plastic materials, specially developed for chlorine- and water-resisting properties, in the construction of a new water chlorinator. Components such as the injector block, chlorine regulator, valve body and piping are of plastic. Wherever metals are necessary, corrosion-resistant alloys are used. The cabinet is made of polyester-impregnated glass fibre and repainting is unnecessary.

The chlorinator is available from Chlorination Equipment Ltd. in 13 meter sizes ranging from maximum capacities of 0.125 to 40 lb. of chlorine/hr. with a control range of 10 to 1. It is produced in two types: type NM for manual operation and type NA for fully automatic dosing. In this latter unit a vacuum transmitter is incorporated which is responsive to changes in flow and transmits such changes to the chlorine regulator assembly by varying the differential pressure across the control valve.

CPE 1163

knife, which slides between the base of the hopper and feed plate. When the *Mikro-Feeder* is in action, the hopper, filled with material, revolves, and the shearing knife at its base maintains a chosen feed-rate.

The thickness of the shearing knife plus the rotation speed of the hopper determine the feed-rate. This rate



The 'Mikro-Feeder' with shearing knife attached to the housing, between hopper and feed plate.

can be varied from a few pounds to 5,000 lb./hr. by moving a lever protruding through the housing which actuates the variable feed-plate drive and an accuracy of $\pm 1\%$ can be maintained. **CPE 1164**

POLAROGRAPHIC ANALYSER

This 'Tinsley' polarograph by Evershed and Vignoles Ltd., incorporates special features for ease of operation. The small current from the cell is amplified and fed to a pen recorder; ancillary circuits cancel out extraneous current and zero adjustment is provided. CPE 1165

'HOT' NEWS ABOUT EPOXY RESINS

Epoxy resins have been put to a variety of applications where there are temperature and corrosion problems; a recent interesting example is the use of an *Araldite* coating on the coil of a thermostatic device for controlling the temperature of a bath. The coil is a bimetallic one which unwinds as the temperature of the bath increases, and the resin coating must withstand the mechanical stresses applied when the dissimilar metals expand and contract, as well as accommodating movement in the coil unit itself.

The resin seals the entire coil, eliminating the risk of corrosion which might result from the setting up of an electrical field by the dissimilar metals. It enables the unit to be used for the temperature control of bath media up to 95°C.

The epoxy resin coating is produced by Ciba (A.R.L.) Ltd. **CPE 1166**

TEMPERATURE MEASUREMENT

Equipment for temperature measurement using thermocouples and a new series of d.c. amplifiers is said to have an accuracy as good as 0.25% of range. The instrument is available in ranges as sensitive as $2\frac{1}{2}$ mv. or 50°C. full scale. It is fully potentiometric in operation and calls for no current from the thermocouple to make its measurement.

According to the makers, Fielden Electronics Ltd., the output circuit is independent of any resistance change within wide limits. **CPE 1167**

★ *American Developments in Brief* ★

A new drying oven for use in paper chromatography has been developed by New Brunswick Scientific Co. Special features include a metal-reinforced safety glass door which affords a continual and complete view of the drying action or the colour development of the chromatograms, thereby eliminating need for repeated opening of door. The oven heats rapidly to a pre-set temperature of 110°C. within about 20 min. and three full-sized sheets ($18\frac{1}{4}$ in. by $22\frac{1}{2}$ in.) can be accommodated simultaneously. **CPE 1168**

* * *

A new grade of activated carbon for use as a catalyst support material is available from Union Carbide International Co. Combining high activity, strength and porosity, it is expected to give better performance than previous grades in a wide variety of uses other than as a catalyst support. Manufactured from a specially selected petroleum derivative, the new activated carbon is in the form $\frac{3}{16}$-in. diam. pellets and has a bulk density of 0.45 g./ml. **CPE 1169**

* * *

A rotary paddle feeder which delivers a constant, uniform stream of small, granular material, is announced by Richardson Scale Co. A series of paddles revolves around a stable drum within a housing and, it is claimed, this design prevents 'pile-up' of material and provides a unique self-cleaning feature. **CPE 1170**

Can Calcium Carbide be Made in New Zealand?

For New Zealand, seeking to set up chemical industries of her own, calcium carbide manufacture based on indigenous raw materials seems an attractive possibility. In this article, the practical problems are discussed in the light of the country's power resources, raw materials and general economic position.

By T. Hagyard

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Fig. 1. Map of the South Island, showing position of existing generators and rivers of potential power. Numbers indicate known mineral deposits referred to in this article. The shaded areas show the relatively *flat* regions, the rest being mountainous.

NEW ZEALAND is once again experiencing exchange difficulties due, in the main, to its predominantly agricultural economy and lack of overseas earnings from other than agricultural products. Efforts to improve this situation have, in the past, developed a diversity of secondary industries based on imported materials such as textiles, metals, plastics and chemicals and, whilst these industries do help the economy, they do not produce overseas exchange and they require imports of raw materials.

Chemical industry producing exportable products based on local raw materials would be attractive and, in fact, the paper and pulp industry is one such and is now established and contributing its share of exports. That large-scale chemical operations can be carried out economically in New Zealand is also proved by the production of 1 million tons of superphosphate annually at prices around £10/ton. This industry, however, is a service to agriculture, not an exporting industry, and in the same category must be included the existing local manufacture of some agricultural spray chemicals and the like on a scale suitable to the modest home market.

Industries based on electrochemical or electrothermal processes using cheap hydroelectric power could provide additional export income as well as serving the home market. Those such as calcium carbide and magnesium metal, which utilise wholly local raw materials, are at first sight more attractive than the aluminium industry, which would need to import bauxite, but, in fact, most aluminium producers operate in this way and, as will be shown below, New Zealand is potentially attractive, by virtue of its power resources, for the manufacture of all three products. Only calcium carbide will, however, be dealt with here.

Power resources

With minor exceptions, all power generation, hydroelectric and other, is carried out by the State Hydroelectric Department which has a statutory monopoly. The North Island, carrying 1½ million people, is somewhat short of power and there is little prospect of a large surplus being available there in the foreseeable future. The South Island, population 670,000, has now, and will have for many years to come, quite a large surplus of power. The present position and that estimated in a 1957 White Paper for the near future is as below:

Year	*Peak load Mw.*	*Generating capacity, Mw.*
1957	270	434*
1963	513	613†
1970	793	1,093‡

* Existing
† On completion of Roxburgh
‡ On completion of Benmore

There thus appears to be a surplus of 100 to 300 Mw. above peak demand up to 1970 even if no further stations are built than are at present in hand. There is a still larger surplus of off-peak power. It was intended to transmit the surplus *via* a Cook Strait cable to the power-deficient North Island, but recent Government decision has been to delay this scheme and it may, or may not, be put into practice. In either event there remains in addition further unexploited hydro potential in the South Island of an estimated 4,000 to 6,000 Mw.

The disposition of the present generating capacity is shown in Fig. 1. The map is shaded in the relatively *flat* areas, the rest being mountainous. The rivers shown are those of possible power potential.

Considerations such as those above have been brought to the notice of the present Government, in particular by a recent speech in the House of Representatives by Mr. M. A. Connelly, M.P., and various favourable ministerial statements have been made in response. Thus Mr. Watt, Minister in charge of the State Hydro Department, stated in a White Paper, 'Electric Power Development' (1958): 'The development in the South Island of manufacturing industries using large quantities of electricity will be encouraged by the Government.'

The way having thus been apparently cleared of obstructions, what of the other necessary requirements for a carbide industry?

Markets

Previous suggestions for the establishment of a carbide industry in New Zealand have been estimated on local consumption of carbide, still quite small at rather over 2,000 tons p.a. In recent years local consumption of organic chemical products derived from acetylene has, however, been increasing steadily. In Australia this tendency is even more marked and chemical uses for carbide have now expanded well beyond the manufacturing ability of that country, leaving some 15,000 tons to be imported annually. It is hoped to satisfy the Australian demand for carbide from the New Zealand industry, if established, and at the same time to replace some imports of vinyl plastics by local production in New Zealand. The possibility also exists that some of the U.K. imports of 50,000 tons p.a. may be supplied from the New Zealand industry. The more highly industrialised countries would thus import from New Zealand a raw material for their diversified chemical industry, whilst New Zealand would use her resources to this end and necessarily restrict chemical manufactures to substances in sufficient demand to be reasonably economic. These include PVC and PVA, the market for which is probably around 2,500 and 1,000 tons p.a. respectively at present. A factor of importance here is the very large amount of paint used for house painting; houses are mostly of timber and roofs mostly of corrugated iron or aluminium and the climate ensures a very large annual demand for paint. Similarly, water reticulation on farms and in gardens requires large amounts of pipe and tubing, often installed on farms by drawing plastic pipe underground by means of a mole plough adapted for the purpose. In view of the rough terrain, lightweight pipe is very attractive, especially in the back country.

Calcium cyanamide is a possible product and could probably be used more economically than any other nitrogenous fertiliser on the comparatively small scale required to satisfy local demand. That this demand is, in fact, small whereas the demand for phosphates is very large, is due to the type of grassland culture responsible for most of the agricultural output. In the New Zealand climate nitrogen fixation by soil organisms is very effective in grasslands and farmers normally use little, if any, nitrogenous fertilisers. The opinion is also held that cyanamide is not a satisfactory top dressing for pastures. Market gardening, where cyanamide might be used effectively, is not on a sufficient scale appreciably to affect the demand. Consequently cyanamide has been omitted from the suggested initial scheme, although later, especially if converted to urea, it might become a factor.

A modest initial production, it is suggested, might be as follows:

	Tons p.a.
Calcium carbide for export ..	15,000
Calcium carbide to replace present imports	2,100
Manufacture of 2,500 tons p.a. PVC	3,200
Manufacture of 1,000 tons p.a. PVA	2,500
Total	23,000

Raw materials for such an initial unit would be: coke, 16,000 tons p.a.; limestone, 40,000; and salt, 3,000 tons p.a.

This represents one furnace of about 11,000 kw., but since it is presumed that power would be supplied by the State Hydro, future extensions of the industry would involve only building more or larger furnaces, not also having to build the generating plant. Output could then be expanded rather quickly if found necessary. If half the U.K. imports were also provided, the output would be 48,000 tons p.a. and power about 20,000 kw., still small compared with the South Island supply.

Raw materials

One ton of 80% carbide requires approximately 0.98 ton of calcium oxide and 0.65 ton of coke together with minor quantities of anthracite, pitch and sheet steel for electrodes and for packaging.

Limestone is widely distributed in the South Island but, being used mainly for agricultural purposes or for cement, full analyses are few. Known deposits of high purity are less numerous but fairly widespread. Available analyses nearly all omit the phosphorus content, all-important for this application, and this factor reduces the *known* deposits of a sufficiently low phosphorus content to three in number. Many more deposits are known of sufficient purity provided their (unknown) phosphorus content is sufficiently low. The known deposits have been reported as:

*Map ref.**	*Deposit*	$CaCO_3$ %	P_2O_5 %	*Reserves, million tons*
1	Ngarua	98.5	0.016	3
2	Kellard Pt.	96.6	0.015	7
3	Millburn	97.0	0.018	Probably large

* See Fig. 1

For New Zealand conditions where gas works do not operate on a large scale and where coke ovens in the usual sense do not exist, anthracite, not requiring carbonising, would be ideal as the source of carbon. With the exception of the Fox River deposits on the West Coast north of Greymouth, the author knows of no anthracite deposits of suitable size. The Fox River deposit is in precipitous bush without access and quite undeveloped as yet and therefore must be ruled out for the present.

The municipal gas works at Christchurch and Dunedin might manage to supply coke up to around 15,000 tons p.a. and they have a selection of coals of suitable analysis to operate on. Thus blends of the coals listed in Table 1 would be expected to give a suitable coke.

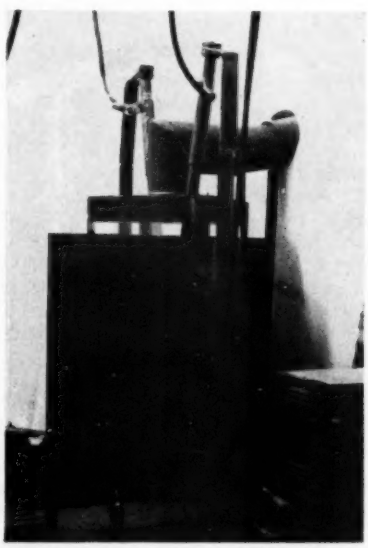


Fig. 2. Experimental carbide furnace at the University of Canterbury Chemical Engineering Department.

Table I. Analyses of Coals Suitable for Coking

Map ref.	*Mine*	*Moisture (%)*	*Volatile matter (%)*	*Fixed carbon (%)*	*Ash (%)*	*Sulphur (%)*	*P_2O_5 (%)*	*Swelling No.*	*Reserves (million tons)*
4	Strongman	7	39	47	2.2	0.5	0.008	2½	6
5	Denniston	3	37	54	3.3	1	0.016	9	Failing
6	Sullivan	2	31	62	4	1	Similar ?	9	New mine
7	Dobson	2	42	50	5.6	2	0.009	9	6
8	Liverpool	2	35	57	2.6	0.5	0.07	9+	1
Possible alternative:									
9	Ohai	16	35	45	3.7	0.2 to 0.5	0.004	0	15

Table 2. Port Facilities

Port	*Limitations on ships*		*Local engineering shops*	*Availability of sites*
	Max. draught (ft.)	*Max. length (ft.)*		
Nelson	22	550	Fair	Available
Christchurch	33	800	Good	Ample
Timaru	26½	600	Fair	Ample
Dunedin	32	800	Fairly good	Restricted
Invercargill	29½	600	Fair	Ample

The first five coals tabulated are all on the West Coast and coke ovens would probably have to be erected to ensure the desired output. As an alternative the sub-bituminous coal deposits in the Ohai field in the southern part of the South Island, indicated in the last line of the table, are of interest provided that on distillation they give a char suitable for a carbide furnace. Very similar coal is carbonised in the North Island in the Waikato in Lurgi vertical retorts with direct contact heating, and such plant would appear to be very suitable for producing a char for carbide manufacture. Such coal is within reasonable distance of one known and other possible limestone deposits of suitable quality, one of which, though not fully analysed, lies directly on the coal fields.

Cost of coal is tabulated below, but it is possible that Ohai coal may, by negotiation, be available at less than the price quoted:

COST OF COAL, SHILLINGS/TON

	West Coast coals	*Ohai coals*
At mine	63—69	64
At Christchurch ..	111—118	129
At Dunedin	130—132	110
At Invercargill ..	176—185	88

Other raw material sources

Work is in hand to extend our knowledge of the numerous possible sources of raw materials by more analyses and by small-scale furnace runs in the University of Canterbury Chemical Engineering Department, although the limitations of small-scale tests are realised.

Sufficient anthracite of suitable quality may be available for electrode purposes from the known small deposits, but this question has not yet been examined. Salt is available from the solar salt industry on the north-east coast of the South Island. Sheet steel for electrode casing and for drum manufacture would have to be imported.

Sites

Choice of sites is conditioned by the N.Z. Railways freight charges, which are relatively low for coal, coke and limestone, but high for finished products not in bulk. Thus distance from sources of raw materials is less important than transport cost of products to the main centres and to overseas. All products for the North Island obviously must go by sea.

The most attractive sites are those adjacent to ports large enough for overseas shipping. This rules out all the West Coast ports as being hindered by bars and subject to closure in bad weather.

When the information as to raw materials is complete and when it is certain how power charges are to be affected by location, then it will be possible to determine the most economical plant location having regard to all the factors already cited.

Conclusion

Circumstances now appear to favour the establishment of a calcium carbide industry in the South Island of New Zealand to a far greater degree than in the past. Raw materials are certainly available in the required quantities, including hydroelectric power. The decision of the Government as to how the latter would be charged for and further investigation of raw materials supplies are matters on which the choice of the most economic site now depends.

INDUSTRIAL PUBLICATIONS

Nitrile rubber. Technical bulletin No. H7 from British Geon Ltd., Devonshire House, Piccadilly, London, W.1, provides information on the properties and processing of *Hycar* 1042 nitrile rubber, medium high acrylonitrile-butadiene copolymer basically similar to *Hycar* 1042, but which has been modified to include carboxylic groups in the polymer chain. Curing systems, plasticisers and pigment loading are discussed with, finally, some data on *Hycar* 1072/methyl ethyl ketone cements.

Magnesium. A booklet dealing with the properties and uses of magnesium and its alloys has been prepared by the Magnesium Industry Council, Dickens House, 15 Took's Court, London, E.C.4. Various industrial applications of the metal in cast and wrought form are illustrated.

Precious metals. The technological importance of the precious metals is stressed in a handsome, illustrated brochure received from the Baker Platinum Division of Engelhard Industries Ltd., 52 High Holborn, London, W.C.1. This explains the history and organisation of the Engelhard Industries companies which, although producing a wide diversity of products, are based on the precious metals industry. Platinum and palladium catalysts, laboratory equipment, production vessels, generation of nitrogen and nitrogen-hydrogen mixtures, fused silica and quartz, gas analysis and other subjects are mentioned.

Exhausters. W. C. Holmes & Co. Ltd., P.O. Box B.7, Turnbridge, Huddersfield, describe in their illustrated publication No. 75 the Holmes-Connersville XAS-type exhausters and boosters which are of simple design with no moving vanes, valves, springs or other small parts. Principles of operation and specifications are given.

Recent British Patents

Apparatus for catalytic processes

There is little difficulty in supporting catalyst gauzes or beds, in exothermic processes, when installations or units are small. In large installations the weight of heat-resisting material is many times that of the catalyst and is therefore costly. The present invention aims at overcoming the difficulties in supporting large substantially horizontal areas of catalyst and, simultaneously, reducing to a minimum the time during which gases leaving the catalyst remain at a high temperature.

The proposed apparatus comprises a multitubular heat exchanger. The catalyst, in the form of gauze or of a shallow bed retained on gauze, is situated adjacent to the inlet tube plate of the heat exchanger, and is supported by a series of heat-resisting elements which are spaced between the rows of tube holes in the inlet tube plate and are supported from the plate. The heat-resisting elements may be of various forms and made of any suitable material, such as fireclay or a heat-resistant metal. Two sheets of drawings are appended to the specification. —801,806, *Imperial Chemical Industries Ltd.*

Production of manganese

Manganese is produced from its alloys, such as ferro-manganese alloys, by vaporisation under vacuum or reduced pressure. The raw material is in the form of granules, from 5 to 20 mm. in size. The process is so conducted that there is no apparent melting and the granules retain their individuality until the manganese has been substantially removed. Great importance is attached to raising the temperature in steps. The alloy is heated at 1,100, 1,150, 1,200 and 1,250°C., for 6 hr. at each temperature. Temperature and pressure data are given, pressure being, for example, less than 0.06 mm. of mercury at 1,100°C.

In the first of two examples, 100 kg. of an alloy containing 88% manganese, 4% iron, 7.5% carbon and 0.5% silicon were heated as described in an electric furnace, the pressure being 0.02 mm. of mercury. The manganese volatilised was condensed on a cooled iron tube and removed while still hot, at 1,000°C. The condensate weighed 83.1 kg. and consisted of 99.9% manganese, 0.005% iron, 0.01% silicon, 0.04% carbon, and 0.04% copper. The extraction of the manganese was nearly 100% and the condensation ratio approximately 95%. In the residue, of 11.8 kg. weight, readily removed by scraping, the granules had retained their original shape and volume.—803,256, *Pechiney Compagnie de Produits Chimiques et Electrometallurgiques (France).*

High-density polythene

For several years, it has been known that ethylene and other olefines can be polymerised using aluminium alkyls as catalysts. To increase the molecular weight and density of the polymers, to improve their physical properties, and to carry out polymerisation at comparatively low temperatures and pressures, the use of a mixed catalyst is proposed. The components of the catalyst are: (1) a halide of a metal such as titanium, zirconium, hafnium or germanium; (2) an organic phosphorus compound; and (3) at least one component selected from an organo-metal halide of defined general formula, a mixture of an organic halide and a metal such as sodium, lithium, magnesium, aluminium, etc., and a complex hydride of defined general formula. The preferred temperature range is from 50 to 300°F. The most desirable pressure is from 100 to 700 p.s.i.

The organic phosphorus compound is a most important component of the catalyst mixture. In an example, results are compared when one is omitted and included. The substance used was triphenyl phosphine, the other ingredients being titanium tetrachloride, and a mixture of diethylaluminium chloride and ethylaluminium dichloride, prepared in a manner described. Ethylene was polymerised. In the absence of the triphenyl phosphine the molecular weight of the polymer obtained was 9,025 and the density 0.941. In its presence the molecular weight was greater than 100,000 and the density 0.972.

The use of a diluent, an inert organic compound, such as a hydrocarbon, or a halogenated hydrocarbon, kept liquid by adequate pressure, is recommended.—803,198, *Phillips Petroleum Co. (U.S.A.).*

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of December 1958 are as follows:

Plant Construction Index: 178.5

Equipment Cost Index: 165.2

(June 1949 = 100)

£ s d

Boiler feedwater treatment

The object of the invention is to minimise the formation of scale and incrustations in pre-boiler equipment, such as economisers, feed pumps, injectors, and the like, and also in cooling water systems. For this purpose, it has been known to have present in the water polyphosphates and/or tannins. The effect of these additives is claimed to be much increased by adding soluble magnesium compounds, so that the sum of those added and those originally present in the water is from 0.10 to 2.0 times, preferably 0.20 to 1.0, the calcium hardness of the water, expressed in terms of calcium carbonate. The concentrations of tannin, such as chestnut tannin, and of polyphosphates, are from 2 to 20 and 0.2 to 5 p.p.m. respectively.

The preferred polyphosphate is sodium hexametaphosphate. Also suitable are sodium tripolyphosphate and tetrasodium pyrophosphate. — 802,875, *Imperial Chemical Industries Ltd.*

Vanadium alloys

The invention relates to improvements in high-tensile alloys, especially those containing vanadium. Substantially pure vanadium has not a high tensile strength, and compares unfavourably in that respect with other metals and alloys used for structural purposes. The inferiority is very marked at elevated temperatures. It has been found that an alloy of high tensile strength can be made from 20 to 50% of titanium, and from 1 to 10% of aluminium, silicon, chromium, or mixtures thereof, the balance consisting of vanadium. The data for the new alloys are tabulated. In one instance an alloy consisting of 50% titanium, 5% silicon, and 45% vanadium has an ultimate tensile strength of 160,200 p.s.i. at room temperature and 94,000 p.s.i. at 700°C. The corresponding values for vanadium are 49,100 and 25,500 p.s.i.—800,120, *Armour Research Foundation (U.S.A.).*

The foregoing abstracts are published by permission of the Controller of Her Majesty's Stationery Office. Copies of specifications can be obtained from the Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2, price 3s. 6d. each.

Company News

Monsanto Chemicals Ltd. has announced an agreement with Scientific Design Co. Inc., New York, and its affiliates, under which the latter will erect at Newport, Monmouthshire, a new plant to produce 15 million lb. p.a. of maleic anhydride by continuous catalytic vapour-phase air oxidation of benzene.

The plant is scheduled for completion during the second half of 1960. It represents a considerable expansion of Monsanto's existing maleic anhydride production in the United Kingdom and the company states that, in addition to meeting all foreseeable future requirements of British industry, it will enable the company to develop export business which has not been possible from its present operations.

*

Solway Chemicals Ltd. have decided to expand their sulphuric acid and cement capacity at Whitehaven, Cumberland, by 50%. Their existing plant, which was started up in 1955 and described in CHEMICAL & PROCESS ENGINEERING, 1956, **37** (1), 5-7, is producing both sulphuric acid and cement at the rate of 100,000 tons p.a.

Solway are a subsidiary of Marchon Products, both companies being members of the Albright & Wilson Group.

*

A one-day symposium on ' Instrumentation in the Process Industries ' was recently organised by Sunvic Controls Ltd. It was attended by more than 50 directors and technical/commercial executives from other companies in the A.E.I. group as well as from chemical and petroleum companies and electricity authorities. Chairman of the symposium was Mr. N. R. Davis, managing director of Sunvic Controls.

Considerable emphasis was placed on data processing and automatic computation, particularly in relation to possible applications in fully automatic plant control. The commercial implications of an increasingly important role for instrumentation were also considered.

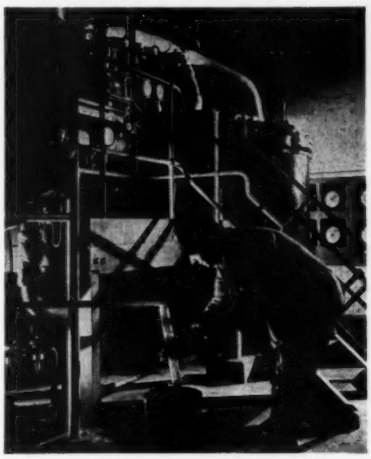
*

The formation of a new Belgian company which will manufacture polythene has been announced by Union Carbide Corporation, U.S.A. To be named Cobenam S.A., it will be owned jointly by Union Carbide and the Belgian company, Société Chimique des Dérives du Pétrôle S.A. (' Petrochim ').

Plans call for the construction of a plant having an initial capacity of 30 million lb. p.a. of polythene, with production estimated to start in mid-1960. The plant site will be located near Antwerp, between the Petrochim chemical plant and refinery of the Société Industrielle Belge des Pétrôles, from which it will receive its raw material. Technical know-how will be provided by the Union Carbide organisation.

*

A licensing and royalty agreement that has recently been signed by Ionics Ltd., U.S.A., and the Permutit Co. Ltd., London, is aimed at furthering the application of membrane-type water desalting plants. Permutit, one of the world's largest and oldest water-treatment equipment organisations, becomes Ionics' licensee for the manufacture and sale throughout most of the British Commonwealth of ion-exchange membranes and equipment covered by Ionics' British patents. The electrodialysis process pioneered by the American company is claimed to be the most economical yet developed for the purification of brackish waters containing from one-half to one-twentieth as much salt as sea-water.



SILICONES PLANT

Ten years ago silicones were imported to Britain in small curiosity quantities. Last year the country used nearly 1,000 tons of silicone products, a substantial proportion of them manufactured in I.C.I. Nobel Division's plant at Ardeer factory in Scotland. Here a worker is seen taking a sample during the processing of silicone fluid at the plant.

Orders and Contracts

Davey, Paxman & Co. Ltd. have received from Cellulose Development Corporation an order to the value of over £50,000 for the supply of five large rotary vacuum filters, a digestion tower and a soaking machine. It is part of a £250,000 contract for equipping a paper pulp mill in China.

*

A new contract for a P. A. Venturi gas scrubber has been given to Chemical Construction (G.B.) Ltd. by John Allen & Co. (Glenpark) Ltd., for the removal of lead fume from gases from rotary and reverberatory furnaces at their Glasgow works.

*

British Oxygen Linde Ltd. has been awarded a contract for a tonnage oxygen plant worth nearly £750,000. The contract was placed by Humphreys & Glasgow who are building Britain's first Lurgi pressure gasification plant for production of towns' gas at Westfield, Fifeshire, for the Scottish Gas Board.

The Westfield project will use oxygen and superheated steam for the complete gasification of low-grade coal which is unsuitable for normal gas-making processes. The ultimate output of towns' gas will be 30 million cu.ft./day.

The oxygen plant, which will be entirely of British design and manufacture, is being built by British Oxygen Engineering Ltd. It operates on the *Tonnox* internal compression system which has a number of novel features. The plant will be capable of producing 200 tons/day of oxygen and is scheduled to go into production during the latter half of 1960.

*

We learn from Integra, Leeds & Northrup that their associates, the Leeds & Northrup Co. of Philadelphia, have received a contract valued at £225,000 from the Argonne National Laboratory for complete instrumentation, and control systems for the second experimental breeder reactor (EBR-2), now under construction at the Atomic Energy Commission's national reactor testing station.

The EBR-2 will be the first civilian power reactor experiment to operate on recycled fuel. Its primary objective will be to obtain engineering and operational information applicable to full-size central station power plants. It will be an integral power plant and will include a complete fuel processing and fabrication facility, in addition to the reactor, heat-transfer systems and steam-electric plant.

Personal Paragraphs

Left to right: G. C. Tett, T. C. Finlayson, H. V. Potter.

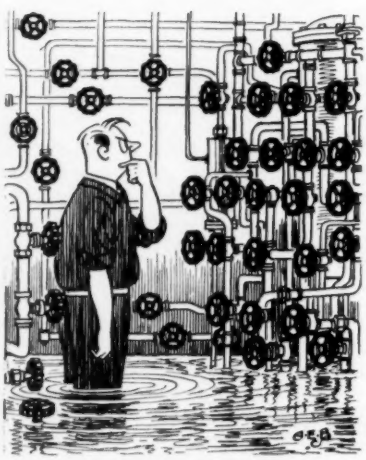
★ **Mr. G. C. Tett,** formerly a managing director and chief executive, has been appointed chairman and managing director of Esso Petroleum Co. Ltd., following the retirement of **Sir Leonard Sinclair.** Mr. Tett joined the company in 1928 as an assistant in their technical sales department and held a number of important posts between then and 1949, when he became general sales manager of Esso Petroleum. In 1951 he was appointed a director of the company and in 1956 he became a managing director. In 1957 he assumed the duties of chief executive. Sir Leonard Sinclair completed 50 years' service with Esso last June. His early years were spent in Manchester, but subsequently he was appointed to a series of successively more important posts in other parts of the country until he was appointed a director in 1943 and chairman and managing director in 1951.

★ **Mr. C. R. Wills,** has been appointed general manager of Acheson Colloids Ltd., Plymouth.

★ **Dr. R. P. Linstead,** F.R.S., rector of the Imperial College of Science and Technology, becomes a Knight Bachelor in the New Year Honours List. Others accorded the same honour include **Mr. E. J. Pode,** managing director of the Steel Company of Wales Ltd., and **Dr. K. T. Spencer,** Chief Scientist, Ministry of Power. Among those who receive the C.M.G. is **Mr. C. Waite,** chairman and joint managing director of Consolidated Tin Smelters Ltd., while the C.B.E. is conferred upon **Mr. S. E. Clotworthy,** managing director, Northern Aluminium Co. Ltd.; **Dr. M. Cook,** chairman, I.C.I. Metals Division; **Mr. T. C. Finlayson,** chairman, Woodall-Duckham Construction Co. Ltd.; **Mr. P. T. Fletcher,** Deputy Managing Director, Industrial Group H.Q., Risley, United Kingdom Atomic Energy Authority; **Mr. R. J. Pinder,** managing director, Esso Petroleum Co.; and **Mr. J. McW. Storey,** managing director, Dewrance & Co. Ltd. The O.B.E. goes to **Mr. C. V. Hill,** lately refining adviser, British Petroleum Co. Ltd.; **Mr. P. W. Mummery,** Senior Principal Scientist, Reactor Division, Atomic Energy Research Establishment, Harwell; and **Mr. J. J. J. Page,** lately general manager, Basra Petroleum Co. The M.B.E. is awarded to **Mr. J. C. Evans,** area production manager, Marchon Products Ltd.; **Dr. I. E. Newman,** Principal Research Officer, Division of Industrial Chemistry, C.S.I.R.O., Australia; **Mr. G. B. Tresilian,** lately chemist and metallurgist, Edward Currant Engineering Co. Ltd.; **Mr. S. Wigglesworth,** safety and civil defence officer, I.C.I. Dyestuffs Division; and **Mr. A. L. Wilson,** Explosives Research and Development Establishment, Ministry of Supply.

★ **Mr. H. V. Potter** has retired as chairman of Bakelite Ltd., but will continue as a director of the company. Actively associated with Bakelite Ltd. for more than 45 years, Mr. Potter is one of the pioneers of the plastics industry and worked with Sir James Swinburne and others in the development of phenolic plastics in Britain. He is president of the British Plastics Federation and a past-president of the Plastics Institute. His other offices have included founder chairman of the Plastics and Polymer Group of the Society of Chemical Industry, and chairman of the Association of Chemical and Allied Employers. Mr. Potter is succeeded as chairman of Bakelite Ltd. by **Mr. S. Adams** who has been vice-chairman since 1948.

Comical Engineering Corner



"LET ME SEE, NOW"

★ **Mr. J. Halloran,** foundry manager, Follsain-Wycliffe Foundries Ltd., was recently the subject of a presentation ceremony to mark his retirement after 24 years' service with the company. **Mr. H. M. Jones,** chairman, made a presentation on behalf of the directors, and **Mr. J. R. Binley,** chief metallurgist, on behalf of the staff. Mr. Halloran has completed 50 years' service in the industry.

★ The United Kingdom Atomic Energy Authority have appointed **Mr. L. Grainger** as Head of the Metallurgy Division in the Authority's Research Group at Harwell. He is to succeed **Dr. H. M. Finniston,** who is being released by agreement to take up appointment with the Nuclear Power Plant Co.

★ **Dr. A. L. Elder,** director of research of the Corn Products Co., Argo, Ill., and an authority on medicinal chemicals, proteins and starches, has been chosen president-elect of the American Chemical Society. He will head the Society in 1960. President for 1959 is **Dr. J. C. Bailar, Jun.,** professor of inorganic chemistry at the university of Illinois, who succeeds **Dr. C. F. Rassweiler,** vice-president for research and development of the Johns-Manville Corp. Dr. Elder was head chemical advisor of the War Production Board and co-ordinator of the penicillin programme in World War 2.

★ The Pyrene Co. Ltd. announce the death of **Mr. W. E. Wright,** late director, who was responsible, primarily, for the metal finishing division. He joined the company nearly 30 years ago and pioneered the use of phosphate coating processes on a production scale in Britain.

★ **Mr. W. P. Ryce,** sales representative of Orobis Ltd. since 1954, died recently after a short illness. He joined British Industrial Solvents in 1946 as London area sales representative and, in 1954, when Orobis Ltd. was formed jointly by the American Oronite Co. and British Industrial Solvents for the production of oil additives, he was transferred to the new company.

World News

UNITED STATES

Carbon brick plant

Initial shipments totalling nearly 700,000 lb. of a new grade of carbon brick for blast-furnace linings have been made from the new, highly automated plant of Union Carbide Corporation at Lawrenceburg, Tenn., now in continuous full-scale operation.

Completed late last year, the multi-million-dollar plant was designed around a revolutionary process that simultaneously forms and bakes carbon products, reducing processing time from eight weeks to less than eight minutes.

SOUTHERN RHODESIA

Phosphoric acid plant

African Explosives & Chemical Industries (Rhodesia) Ltd. recently commenced production of phosphoric acid. The new plant, near Salisbury, cost some £3¾ million and will produce up to 60,000 tons of triple superphosphate p.a., which is more than enough to meet the Federation's needs.

The company is also to erect a £85,000 plant for the manufacture of aluminium sulphate for water purification, according to a report from Barclays Bank D.C.O.

NORWAY

Saving 60,000 tons of fuel

Borregaard A/S, Norway's largest industrial concern, which produces pulp, paper and chemical products, has completed a wet oxidation plant. This will utilise various refuse products to produce heat and steam, and it is estimated that it will be possible to save 60,000 tons of fuel oil, which is half the concern's annual consumption.

The plant is built according to the Zimmermann process, and Borregaard holds the licence for further development of the patent in Europe. The process yields a by-product of plaster.

ISRAEL

Phosphorus factory

Koor Crafts & Industries Co. Ltd., Haifa, in co-operation with some other local enterprises, have prepared plans for building a factory for producing elemental phosphorus at Dimona in the Negev. The plant will require some 125,000 tons of phosphate and 50,000 of sand. The factory will produce 10,000 tons p.a., thus bringing Israel to third place in production after the United States and the U.S.S.R. Only some 1,500 tons are required for local use and the remainder will be available for export. It is reported that the investors include the Haifa firm of Fertilizers & Chemicals Ltd. and also a British company.

HUNGARY

Improved gas manufacture

A process for obtaining more gas and coke, increasing at the same time the pressure and caloric value of the gas produced, has been introduced at the Györ gas works. The essence of the process consists in mixing a certain quantity of bitumen to coal.

Experimental operation lasted ten days and results showed that an addition of 5% of bitumen to coal raised gas output by about 2,000 to 3,000 cu. m. Shatter index rose at the expense of small coke, together with the total of coke output.

JAPAN

Terephthalic acid

The first commercial plant utilising the liquid-phase air-oxidation process for the manufacture of terephthalic acid from petroleum-based feedstocks is now in operation for Mitsui Petrochemical Industries Ltd. at Iwakuni City. The plant start-up was accomplished in just over one year from the signing of the agreement.

The terephthalic acid plant is another unit of Mitsui's $30-million petrochemical project, the largest in Asia, which includes ethylene oxide by direct air oxidation, ethylene glycol, cumene by alkylation of benzene with propylene, and para-xylene, all these units being designed by Scientific Design Co. Inc. The plant's output will be diverted to the Toyo Rayon Co., one of the eight Japanese firms financing the project. Toyo will ultimately use the chemicals to manufacture synthetic textile fibres of the polyamide and polyester types.

DOMINICAN REPUBLIC

Fertiliser imports

The import of 156,119 tons of chemical fertilisers valued at $9.6 million to the Dominican Republic since 1950 is reported by the Republic's Department of Trade and Commerce. In addition, 90,973 tons of home-produced fertilisers have been provided for farmers under the government's intensive agricultural campaign.

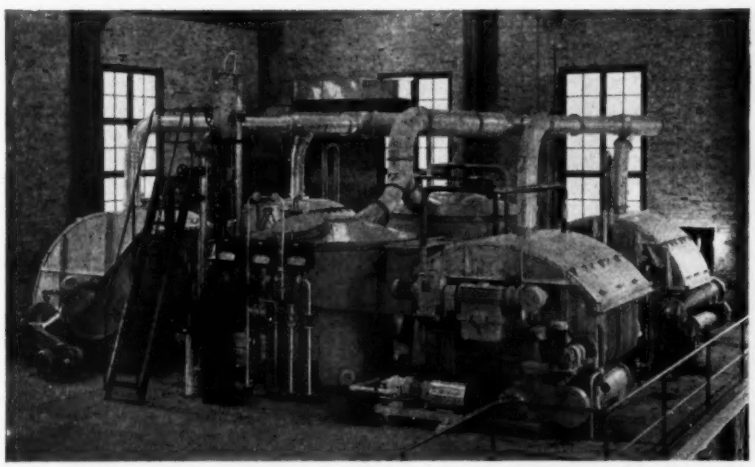
SWEDEN

Novel pulp mill

Billeruds A.B., the large West-Swedish forest industry company, which last year celebrated its 75th anniversary, has recently put into operation a Kr.4-million experimental pulp mill at its Jössefors plant. The mill has a capacity of 10 tons/day of highly processed pulp and includes some novel equipment.

The mill has been designed partly on the basis of experiences gained at the experimental bleaching plant built at Jössefors in 1953-54. Several of the results attained there have been applied in the current production techniques, *e.g.* viscose pulp from birchwood and acetate pulp. Provision has been made for a maximum of flexibility, continuity and automation throughout the various operations, and radioactive isotopes are used for following the processes.

The cooking plant is equipped with



Filter section of the bleaching plant at the new Swedish pulp mill.

a continuous, two-stage Kamyr digester, the only one of its kind in the world, which will be used for testing a number of processes, including continuous two-stage sulphite and prehydrolysis kraft cooking.

The bleaching plant has four towers for continuous bleaching and the combination of the individual units in the plant has been made flexible in order to permit of testing a large number of bleaching schemes with the use of both conventional and new bleaching agents. The chemicals required for cooking and bleaching are manufactured continuously in the basement from raw materials supplied by the adjacent main factory.

CZECHOSLOVAKIA

Engineering on show

A big international trade fair is to be held at Brno from September 6 to 20. This will be a specialised exhibition devoted to engineering products, so that it will link up with the three big exhibitions of Czechoslovak engineering which have been held at Brno from 1955 to 1957, and at which the Czechoslovak foreign trade corporations exporting machines and equipment—Kovo, Motokov, Strojexport and Technoexport—displayed goods. The forthcoming trade fair will cover almost twice as much space as the exhibition held in 1957. On display will be products of the engineering and metallurgical industries, raw materials and semi-manufactures and some products of the engineering industry of a consumer character.

BRAZIL

New companies and factories

The firm of Corsolo Industria e Comercio de Corretivos de Solos S.A. has been set up in Sao Paulo with an initial capital of Cr$4½ million for the manufacture of fertilisers and insecticides. The capital has been subscribed by Amynthas Jaques de Morais, Rio de Janeiro.

The new sulphuric acid factory of 'Quimbrasil' was opened in October and will produce 120 tons/day which will be used in the manufacture of superphosphates.

Industria de Oleos e Derivados Quimasil S.A. Campinas, Sao Paulo State, has been set up by local citizens with an initial capital of Cr$2 million for the processing of vegetable oils and fats.

A company for the manufacture of adhesives has been set up in Sao Paulo, called Cibracol S.A. Companhia Industrial Brasileira de Colas.

MEETINGS

Institution of Chemical Engineers

February 12. 'Mass Transfer to Drops of Liquid Suspended in a Gas Stream,' by Prof. F. H. Garner, P. Kendrick and J. J. Lane. 'Hold-up and Liquid Film Coefficient of Packed Towers,' Part 1, by J. F. Davidson, E. J. Cullen, D. Hanson and D. Roberts. Part 2, by J. F. Davidson, 'Gas Liquid Mass Transfer in Agitated Vessels,' by P. H. Calderbank, 'Heat and Mass Transfer Accompanying the Absorption of Ammonia in Water,' by G. G. Haselden and S. A. Malaty, 9.30 a.m., Church House, London, S.W.1.

March 4. 'Reynolds' Analogy and Mass Transfer,' by Prof. F. H. Garner, V. G. Jenson and R. B. Keev, 6.30 p.m., Birmingham College of Technology, Costa Green, Birmingham.

Society of Chemical Industry

February 10. 'Extraction of Thorium,' by W. D. Jamrack, R. A. Wells and J. H. Buddery, 6 p.m., 14 Belgrave Square, London, S.W.1.

Royal Institute of Chemistry

February 9. 'Gas Chromatography,' by J. H. Purnell, 6.30 p.m., Leeds University.

Society of Instrument Technology

February 18. 'Variable Area Flowmeters,' by F. C. Whalen, 7 p.m., King's College, Stephenson Buildings, Newcastle-on-Tyne.

February 27. 'Data Handling in the Process Industries,' by A. Parsons, 7.15 p.m., Scottish Building Centre, 425 Sauchiehall Street, Glasgow.

March 5. 'Information—Communication and Usage in an Oil Refinery,' by J. M. Keating, A. Millien and D. S. Townend, 'Steam Raising in Industry,' by G. Nonhebel, 'Handling of Data from Process Operations in a Chemical Plant,' by F. G. Webster, 5.30 p.m., Mansion House, Portland Place, London, W.1.

Institute of Metals

February 26. Symposium on Corrosion, 2 p.m., Sheffield University, St. George's Square.

March 4. 'Behaviour of Steels During Hot Working, with Particular Reference to Hot Extrusion Processes,' by P. Sukolski, 6.30 p.m., Central Library, Manchester.

March 5. 'Plastic-coated Sheet Steel,' by F. H. Smith and W. E. Martin, 7.30 p.m., College of Art, Green Lane, Derby.

The Leonard Hill Technical Group—February

Articles appearing in some of our associate journals this month include:

Petroleum—Utilisation of Residual Fuel Oil; Solid Petroleum Hydrocarbons and Their Effect on Wax Properties; Gas Chromatography in the Oilfield.

Paint Manufacture—Paint Industry in the Scandinavian Countries; Packaging Inks for Film and Foil; Hazards in Paint Factories.

Automation Progress — Process Control by Computer; Data Sampling—Theory and Practice; Tape Control for Measurement and Machining; Automatic Control of Effluent Neutralisation; Measurement and Control of Processes.

Atomic World—How Do They Select Nuclear Power Station Sites?; Description of the Argonne Low-power Reactor; Special Power Excursion Test Reactor.

Corrosion Technology—Pipeline Protection in the Middle East, 2; PVC Tapes for Pipe Protection.

Dairy Engineering—Instrument Control for Dairy Automation; Instrumentation for Automatic In-place Cleaning.

Food Manufacture—Experiments in Cooking Sardines; Technology of Smoked Foods.

Manufacturing Chemist—Analysis of MCPA; Purine Analogues in Cancer Therapy.

World Crops—Weed Control in Temperate Regions; Potato Blight; Protection Against Termites.

Institution of Mechanical Engineers

February 17. 'Pumping of Liquids of Unusual Viscosity, Volatility, or of Solid or Gas Content,' 6 p.m., 1 Birdcage Walk, Westminster, London, S.W.1.

Junior Institution of Engineers

February 13. 'Energy Demands in Britain and a Fuel Policy,' by J. G. King, 7 p.m., Pepys House, 14 Rochester Row, Westminster, S.W.1.

February 27. 'Computers and Materials Handling,' by W. J. Kease, 7 p.m., Pepys House.

Using Plastic Sheet

This book,* which is the fourth of a series covering plastic applications, is a useful work for the reader with a practical bent. In addition to the description of sheet-forming processes the selection of suitable materials, equipment and moulds is indicated. It also discusses the decoration of sheets and assesses production and other costs.

It must be remembered that these last are for the United States' industry, as is, in fact, the whole book including spelling, technical jargon and listed equipment. Nevertheless this work is well worth reading and sets a good practical level. J. H. MARTIN

**Plastic Sheet Forming*, by Robert L. Butzko. Chapman & Hall Ltd., London, 1958. Pp. viii + 181, 36s.

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